ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Vol. XXXIX., No. 6.

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INTERCEPTING SEWERS, costing $3,300,000, are to be built at Chicago, to prevent the discharge of sewage into the lake by turning the flow westward to the river and thence to the Drainage Canal. The ordinance for this important work has been passed by the council and signed by the Mayor, and it is stated that bids for the construction will soon be called for. The cost is to be defrayed from the water fund, and this has caused an opposition movement on the West Side, the claim being made that this fund should not be used for sewers, the people failing to recognize that the work is not so much for the disposal of the sewage as for the improvement of the water supply. The 12th St. and 22d St. sewers are to be built first, as they will stop 40% of the sewage now discharged into the lake. The former will be from 2½ to 8 ft. diameter, and the latter from 3 to 8 ft. diameter. The 39th St. sewer will be 20 ft. in diameter from the lake to the river, and its branch extending south to 75th St. will be 6 to 12 ft. in diameter. The Lawrence Ave. sewer will be 16 ft. diameter from the lake to the river, and its branches stretching northward and south to Lincoln Park will be 2½ to 8 ft. diameter. The pumping stations at 63d, 70th and 73d Sts. will be abandoned, the land sold and the machinery adapted to the requirements of the new pumping stations to be erected at some point along the 39th St. and the Lawrence Ave. conduits. The location of the other stations has not been decided upon. The city will still maintain the pumping stations at 69th and 79th Sts., and at Kensington. As already noted in our columns, the city will build the sewers and pumping stations and put in the pumping plant, and then turn them all over to the Drainage Board, which has undertaken to maintain them. The length and cost of the new intercepting sewers and pumping plants will be as follows:

	Length, miles.	Est. cost.
Twelfth St. sewer	1¼	$160,000
Twenty-second St. sewer	1¼	160,000
Thirty-ninth St. sewer	2⅓	850,000
Arm of Thirty-ninth St. sewer	4½	850,000
Lawrence Ave. sewer	2¼	450,000
North and south arms of Lawrence Ave.	6¼	225,000
Pumping stations, land, machinery, etc.		605,000
Total cost, estimated		$3,300,000
Total length of new sewers		17 5-6 miles

CONCRETE SEWERS may be used in Chicago, as the result of a visit of a council committee to Reading, Pa., to inspect the concrete sewers at that place. The committee has reported that these are 33% cheaper and much more durable than brick, and has recommended that in future calls for bids for large sewers alternative bids should be invited for concrete and brick.

A SUIT TO PREVENT THE POLLUTION of the Passaic River by the sewage of Paterson, N. J., has just been instituted in the Court of Chancery of the State of New Jersey. The suit is brought by a number of individuals. An attempt has been made to get Jersey City to join in the contest on the ground that its rights in the Passaic River as a source of water supply have been infringed upon by the city of Paterson.

BIDS FOR A NEW WATER SUPPLY for Jersey City will be received on Feb. 23. Bids may be submitted for a gravity supply or for filtered water, the water in the latter case to be taken from the Passaic River. Mr. Geo. T. Bouton is Clerk of the Board of Street and Water Commissioners. Messrs. C. C. Vermeule, 203 Broadway, New York, and Garwood Ferris, of Jersey City, are Consulting Engineers for the city.

NUMEROUS DAMAGE SUITS FOR THE DIVERSION of water from Cork Center Creek for a public water supply have been brought against the city of Johnstown, N. Y., by owners along the stream. A correspondent has sent us the following regarding the suits:

The several suits are to be grouped into batches according to the circumstances governing each group, with separate commissions for each batch or group. Two of these have already had several hearings before their respective commissions, though no decisions have yet been rendered. The action of the claimants on the recent extensions to the water-works and their prospect of securing damages has instigated the claimants on the original constructions to file their claims, which had been allowed to lie unfiled until now, when they have about become outlawed, some of them having but a few weeks to run. The streams involved are well-known water-power streams, the flow being fairly uniform and the fall heavy, and over 30 powers are now developed on the portion of the streams now in question. Prof. Olin H. Landreth, M. Am. Soc. C. E., of Union College, has been retained by the city of Johnstown as the engineering expert on these suits in conjunction with City Engineer Miller, of Johnstown. Water-power litigation is popular on the Cayadutta and the above branches. Besides a number of suits between private parties of greater or less importance, Judge Kellogg, of the Supreme Court, has just handed down a decision granting nominal damages against the Johnstown Electric Light & Power Co., which operates in Johnstown and Gloversville, for alleged interference to the power of mill owners below, but denying an injunction against this company.

A SUIT TO ANNUL THE GARBAGE DISPOSAL CONTRACT recently awarded by the city of Boston to the New England Sanitary Reduction Co. has been instituted by the Merz Universal Extractor & Construction Co., of New York city. The plaintiff alleges that the location of the reduction works was changed from Spectacle Island to the Calf Pasture after the invitation for bids was issued; that the company to whom the contract was awarded knew of the change, but the plaintiff did not; that had the plaintiff known of the change in location it would have bid $45,000 a year, or less, instead of $55,000. The contract was awarded at $47,000 a year, the Arnold system to be employed.

A 67-FT. TRAVELER was blown from the unfinished bridge across the Susquehanna River at Catawissa, Pa., by the severe wind storm which swept up the Susquehanna Valley the morning of Jan. 27. The traveler was completely wrecked.

AT A FIRE IN BOSTON on Feb. 5 six firemen were killed and a number of others were injured by the falling in of the roof of the five-story building in which the fire occurred.

THE MOST SERIOUS RAILWAY ACCIDENT of the week, involving the probable death of 6 persons and the injury of 24, occurred Feb. 3 on the Boston & Maine R. R., at Winter Hill, about five miles from Boston, Mass. It is stated that a local train from Concord ran into the rear of a local from Stoneham, owing to escaping steam, which prevented the engineer seeing the red flag some 300 yards to the rear of the standing train. When the signal was noticed the train could not be stopped on the slippery rails.

THE NORTHWEST LAND TUNNEL of the Chicago water-works extension has recently been the scene of two serious accidents caused by falls of rock and sand from the roof. One man was killed and another fatally injured on Jan. 29, and another was killed on Jan. 31. During the two years that this tunnel has been in progress ten men have been killed and 48 injured or made sick by working in the tunnel, and the Commissioner of Public Works has ordered an investigation made as to the methods of carrying on the work. The city officials claim that the contractors do not exercise sufficient care in the timbering and that unnecessarily charges have been used in blasting. The contractors, Weir & McKechney, claim that the number of men killed, injured and made sick is not greater than is to be expected in such rough and dangerous work.

IN CONNECTION WITH THE DAMAGED BROOKLYN dry dock, the House Committee on Naval Affairs has requested Secretary of the Navy Long to receive testimony from civilian expert engineers on the character of the soil underlying the dock. The purpose is to learn whether the existence of quicksand or other unstable material would make it unadvisable to carry out the plan of rebuilding this dock.

EXPLOSIONS IN COMPRESSED AIR PLANTS, due to the existence of oil in the compressor or pipe line and its vaporization by heated air, the air and the vapor forming an explosive mixture, are discussed by Mr. Frank Richards, in the "American Machinist" of Feb. 3. He says that in single stage compressors working up to seven atmospheres the temperature reached by the air may be high enough to cause ignition, and that if in such cases lubricating oil is fed to the cylinder intermittently in considerable quantities at a time, the conditions may exist for forming an explosive mixture of vapor and air. The method of preventing this set of conditions is to admit the lubricating oil drop by drop. One explosion mentioned by Mr. Richards took place in a long line of pipe in which oil had accumulated at a low portion. Air at 1,700 lbs. was suddenly turned into this pipe, and the air enclosed in it was suddenly compressed and heated, vaporizing the oil and causing an explosion. The possibility of danger due to turning compressed air into a pipe with a little oil in it is not as well known as it should be.

EXPERIMENTS WITH LIQUID AIR were recently made by Prof. Geo. F. Barker, at the University of Pennsylvania. Two gallons of the substance are stated to have been brought in a milk can from New York, where it was made by Mr. Charles E. Tripler. The method of manufacturing it is described as consisting in the compressing of ordinary air to 2,000 lbs. per sq. in., cooling it in a coil and allowing it to expand, producing a temperature of — 191° C. or — 312° F, at which temperature air is a liquid at atmospheric pressure. The experiments included making the liquid boil by inserting an egg in it, which was frozen; also boiling it by inserting a piece of tin which was made as brittle as glass. A rubber tube also became brittle when immersed in it, but platinum and copper were not affected.

WORK ON THE SUBWAY OF THE PHILADELPHIA & Reading Railway, in Philadelphia, is progressing favorably, and those in charge expect to have it in operation by the spring of 1899. Material changes in plans have been made in the line of economy. At 16th St., where a car lift, costing $200,000, was originally proposed, the company has bought the block occupied by the Whitney Car Wheel Works. It will tear down the buildings and substitute inclined tracks for the lift. Instead of ventilating the tunnel portion by a power house and fans, costing $323,000, ventilating shafts will be built into the tunnel. Between 22d and 25th Sts. a strip of land 40 ft. wide has been taken from the south side. The owners of this property claimed $791,435 for damages; but the jury of award appointed by the court has awarded $436,723, and it is not expected that the total will exceed half a million. The original estimate of cost set aside $1,000,000 as the probable amount to be paid for property taken.

THE NEW EAST RIVER BRIDGE, according to the report of the Commission to the Board of Estimates, will require $4,150,000 to meet the proposed expenditures for 1898. Of this amount, $1,640,000 will be expended for real estate covered by the approaches in New York and Brooklyn. The amount to be used in actual construction is $2,500,000, divided as follows: Tower foundations, $695,000; anchorages, $1,115,000; tower and shore spans, $470,000; for cables, $250,000. Work on the cables would begin in September next. Advertisements for steel towers and approaches are being sent out, and bids will be opened on Feb. 28, with an obligation to file a bond of $350,000 on the part of the successful bidder.

THE UNION STATION AT CHICAGO is to be rebuilt in order to provide better and more extensive accommodations. Plans have been prepared by Mr. D. H. Burnham, and await the approval of the Board of Managers, which is composed of the managers of the several roads using the station. The interior arrangements will be changed very considerably, and while the main entrance will still be on Canal St., a wide and convenient entrance from Adams St. will also be provided, leading directly to the train platforms. The cost of the work is estimated at $25,000 to $50,000. This station is the terminal used by the Chicago & Alton, the Chicago, Burlington & Quincy, the Chicago, Milwaukee & St. Paul, the Pittsburg, Cincinnati, Chicago & St. Louis, and the Pittsburg, Fort Wayne & Chicago railways.

A SPIRAL RAILWAY TOWER is being planned as one of the features of the coming Pan-American Exposition at Niagara Falls. The tower would be located on Cayuga Island and the general design is as follows: A steel skeleton circular tower would be built, about 500 ft. high and 80 ft. diameter at the base and 50 ft. diameter 400 ft. above the base. Around this tower, supported by strong brackets, would be a spiral railway, passing ten times around the tower in reaching the 400 ft. platform. The motive power is to be electricity, with various safety appliances used in connection with the track. The spiral itself will be double, providing for independent up and down tracks, 20 ft. apart. The designers of the tower are: Secretary R. C. Hill, of the Exposition company; George A. Ricker, acting Chief Engineer of the company, and C. W. Ricker, electrical engineer of the Buffalo Traction Co. No exact estimate of cost is given, other than that it will cost from three-fifths to two-thirds of the amount expended on the Chicago Ferris wheel.

NEW TERMINAL STATION AT DULUTH, MINN; C., ST. P., M. & O. RY.

In the account of a trip made to the Minnesota iron ranges last summer by a member of the editorial staff of Engineering News, it was noted that the Chicago, St. Paul, Minneapolis & Omaha Ry. was building the foundations for a new station at Duluth, Minn., close to the Union Station, and we are now able to give some plans of the new terminals of this road.

The passenger station has, until recently, been a small frame structure, but it is now replaced by a stone building more in keeping with the importance of the railway and the city. As the company owns the land where its terminal is situated, it preferred to build a station for its own use and alter and improve its terminal arrangements rather than to pay rental for the use of the Union Station, which is a handsome building having a large trainshed.

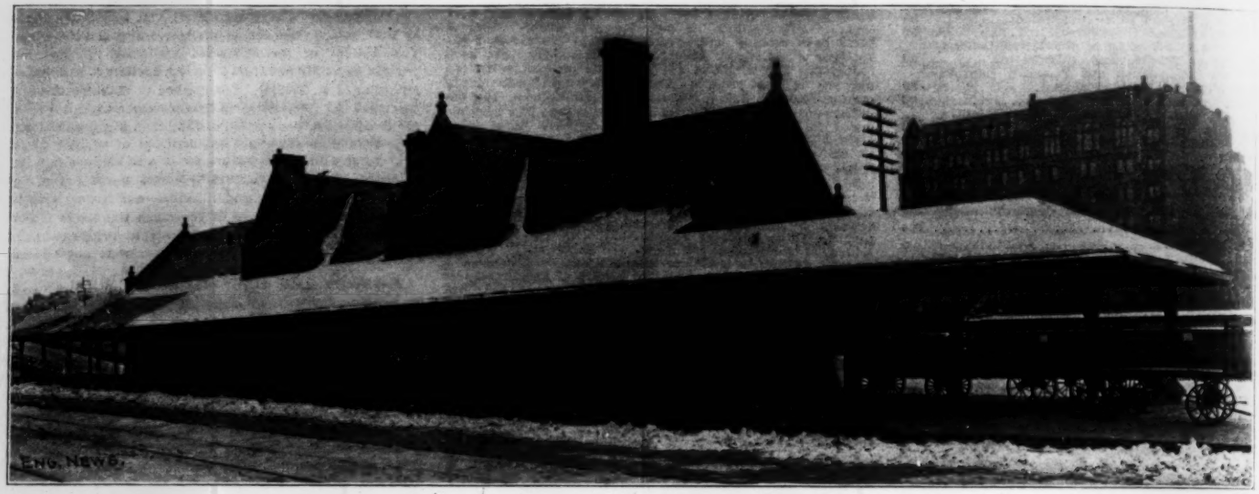


FIG. 1.—VIEW OF NEW TERMINAL STATION AT DULUTH, MINN.; C., ST. P., M. & O. RY.
C. W Johnson, Chief Engineer; C. S. Frost, Architect.

The new station is 163 ft. 6 ins. long and 26 ft. to 36 ft. 6 ins. wide, built of Lake Superior brown stone upon a foundation of stone and concrete supported by piling. The height of the walls is 16 ft. on the street front, and the height from the platform to the eaves of the platform shed on the track front of the building is 9 ft. 4 ins. The roof is of slate, its ridge being 29 ft. 6 ins. above the ground. The main waiting-room is 88 × 28½ ft., with a wainscoting of impervious brick, and a floor of hard maple; at each end is a large fireplace. The woman's waiting-room is 15¼ × 20½ ft., and the ticket office 20 × 16½ ft., while the baggage-room is 28 × 24 ft., with an extension 9½ × 11½ ft. The building is heated by steam and lighted by incandescent electric lamps, the current being supplied from the city circuits.

Fig. 1 is a view of the track front of the building. Fig. 2 is a plan of the building, and Fig. 3 is a plan of the revised terminal arrangements. The design of the floor plan of the building seems open to criticism in regard to the position of the ticket window, which is exactly opposite the main entrance. At busy times persons coming in and going out will interfere more or less with the line of persons waiting to purchase tickets, and this, with the swinging of the doors, will tend to cause confusion in the narrowest part of the building. Again, during the severe winters of the Northwest, persons at the ticket window will stand right in the draft from the doors. These objections might have been obviated in many ways. If it was necessary to adhere to the present general plan, the entrance doors might have been put in the ends of the vestibule, or the ticket window might have been put at one side of the office, nearer to the door leading to the track platform.

The architect for the building was Mr. Charles S. Frost, of Chicago, and the contractor was Mr. David Hood, of Duluth. The cost of the passenger station was $30,000, and that of rearranging the tracks and moving the freight house was $7,000, making a total of $37,000 for the terminal improvements. The work was planned and executed under the supervision of Mr. Charles W. Johnson, Chief Engineer of the C., St. P., M. & O. Ry., to whom we are indebted for plans and other information.

THE POLLUTION OF THE WATER SUPPLY OF CUMBERLAND, MD., BY A PAPER PULP MILL.

By Churchill Hungerford.*

While the national capitol at Washington has been investigating the various sources of pollution of the Potomac, preparatory to improving the quality of its water supply, the city of Cumberland, in Western Maryland, has been compelled by the excessively rapid increase of the contamination of the headwaters of the Potomac to take legal action against the greatest and most offensive nuisance, the Piedmont Pulp & Paper Co. of Piedmont, Md.

The nature and result of the suit has been briefly summarized, at my request, by Mr. Robt. H. Gordon, of Cumberland, Md., one of the Counsel for the State in this case. Mr. Gordon's letter was dated Feb. 5, 1898, and is as follows:

> The suit was a criminal prosecution for pollution of the Potomac River by the State of Maryland under an indictment found by the Grand Jury of Allegheny Co., Md., and was removed to Frederick Co., Md., by the Piedmont Pulp & Paper Co. The trial commenced in Frederick, Md., on Dec. 16, 1897, and ended on Jan. 1, 1898. The only decision so far has been the verdict of guilty by the jury. Judgment on the verdict has not been entered as yet. A motion is now pending for a new trial, based upon alleged improper arguments of State's counsel, and that the jurors had consulted newspaper reports of the trial in the jury room after submission of the case to them.

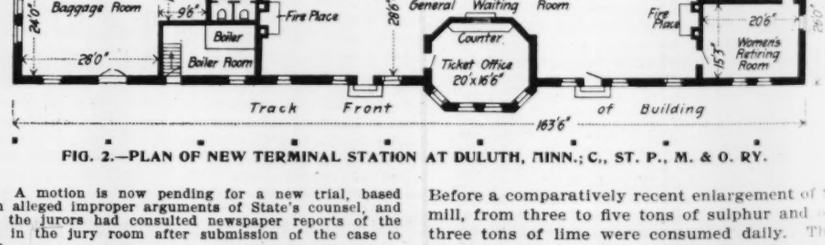


FIG. 2.—PLAN OF NEW TERMINAL STATION AT DULUTH, MINN.; C., ST. P., M. & O. RY.

Cumberland has derived its water supply from the Potomac since 1879. Previous to the installation of the pulp mill the water was considered good, and although possessing a yellow stain at low water and considerable turbidity at high stages, was very generally used for domestic and manufacturing purposes. As the quality of the Potomac deteriorated, various engineers were employed to investigate the availability of Evitt's Creek, a stream about two miles from town, as a source of supply. Some regarded it as ample, others as insufficient. It is a flashy mountain stream with a steep drainage area and rapid run-off, but it could probably be made sufficient to meet all demands by constructing a series of impounding reservoirs. Another serious objection to the adoption of this supply lies in the intervention of a range of high hills between Cumberland and a tunnel a mile or more [illegible] would have to be driven to avoid pumping against a very high head. A deep well near town developed a flow of salt water.

The suit instituted by the people of Cumberland (the State of Maryland vs. the Piedmont Pulp & Paper Co.), developed some interesting and unusual forms of contamination. One witness testified that he cleaned out the privy vaults of Piedmont and emptied their contents into the Potomac by the wagon load; that he did this as often as twice a week at certain seasons of the year, and that there were other men following the same occupation who made a similar disposal of the night soil. The effect of these enormous doses of foecal matter on a stream flowing at a rate of from fifteen to twenty million gallons per diem can be imagined.

The process used by the Piedmont pulp mill for converting the spruce wood into pulp is the well-known "sulphite" process, in which the cementing material that binds the fibers together is dissolved by digesting the wood in bi-sulphite of lime. Forty-five per cent. of the wood is a waste product, appearing in the form of a brown liquor. Before a comparatively recent enlargement of this mill, from three to five tons of sulphur and over three tons of lime were consumed daily. These inorganic substances, together with all matter dissolved from the wood, mainly organic carbon, are discharged directly into the river. The total solids in the river are increased nine thousand parts per million immediately after reaching the pulp mill. There is also sufficient free acid in the discharge to make the river strongly acid. A comparison of the analyses of 1895 and 1897, both made during a low stage of the river, shows an increase in the total solids for the two years of nearly eight thousand parts per million.

This waste liquor from the digestors is, from the

*116 West 69th St., New York city.

very nature of its constituents, a powerful antiseptic, and when it exists in a water in such marked quantities as in the present instance, it undoubtedly causes the most active of the water bacteria to become inoperative, even if it does not actually destroy them. The flow of the river at Cumberland is not over 15% greater than at Piedmont, and the stream runs too rapidly to admit of an appreciable diminution of the suspended matter by sedimentation. Dilution and sedimentation being inconsiderable, the destruction of the organic matter, if any, must be chiefly by biological action. With the water bacteria rendered inoperative by this pulp mill liquor, the night soil of Piedmont, the sewage of Keyser, together with other contaminations of an organic nature, are beyond redemption by any process except distillation.

Mr. Wm. P. Tonry, a chemist, of Baltimore, was employed to analyze samples of the water collected above the pulp mill, and one-fourth mile below, to determine the extent of the contamination from the mill. His results were as follows:

(Parts per 1,000,000.)	Above mill. Clear; no odor, no color; alkaline after boiling.	Below mill. Brown in color; cloudy; strongly acid.
Chlorine	7.14	11.85
Total solids	185.64	9,681.84
Loss on ignition	114.24	7,582.68

When the pulp mill finds other means of disposal for its wastes, the people of Cumberland hope by filtration of the Potomac River, to have again a satisfactory water supply. The problem of disposal that confronts the Piedmont Pulp & Paper Co. is not, however, an easy one to solve.

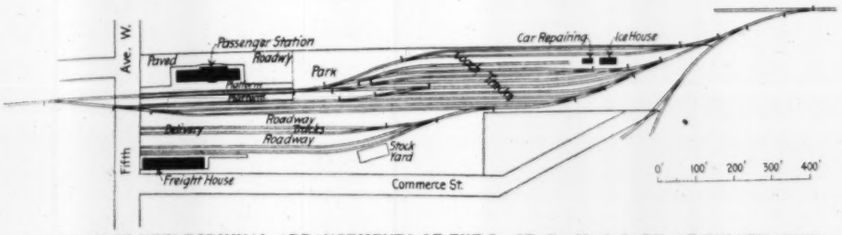


FIG. 3.—PLAN OF NEW TERMINAL ARRANGEMENTS OF THE C., ST. P., M. & O. RY. AT DULUTH, MINN.

veritably preserved, and, although their pathogenic bacteria are destroyed, they are carried along in all their original nastiness to a point where the water bacteria can again perform their good offices. With large quantities of free sulphuric acid still existing in the river at Cumberland, 30 miles below, it is improbable that any marked change can have taken place in the organic matter before it has reached that point.

No trouble was experienced from the mine water of the George's Creek region before the construction of the pulp mill. It constituted but a small proportion of the flow of the Potomac, and in subsequently flowing over a lime stone bed for eight miles, probably purged itself of the free acid and iron in the same manner that the Schuylkill River is relieved of similar impurities. In the last few years, a slimy deposit, attributed to the pulp mill wastes, has appeared on the rocky bed of the river, and this prevents the free access of the acid water to the limestone.

A small experimental filter was constructed at Cumberland in December, 1896, under the supervision of the writer. The bed had an area of 100 sq. ft., and consisted of 12 ins. of sand over 8 ins. of crushed stone. It was designed to operate at a rate of 7,000 gallons per day. The only available sand at that season was crushed Medina sandstone, said to contain 99% of silica. It was washed to remove the dust but proved to be too fine (effective size less than 0.2 mm.) to admit of the admixture of clay and was used pure. Garden soil was sprinkled over the bed, and, as a bacteriological examination of the effluent made before the close of the winter showed a removal of 99.14% of the bacteria, nitrification had probably commenced. The analyst stated that there was neither color, taste, odor or turbidity in the effluent.

The filter continued to do good work until low water. At this stage the river became highly discolored, assuming a brown color almost as deep as that of strong coffee. The acid water being a much better solvent of the coloring matter in the sawdust which is deposited in the river sands in considerable quantities, made the river much more discolored than if it had possessed its normal alkalinity. As above stated, the water then contained several thousand parts per million of solids, 70% of which were organic carbon, and the filter, as might have been expected, failed to make the water potable. The free sulphuric acid alone was quite sufficient to make the filter nothing better than an inefficient strainer. It was operated under these conditions for about six weeks, when the water commissioners tried the experiment of renewing the sand. No change was noticeable in the effluent and a small amount of lime was added to the raw water. In two days the effluent flowed from the filter with only a trace of its former color. Although clear and bright, it is not to be supposed that it was fit for either domestic or manufacturing purposes, as the raw water was

CRIB CONSTRUCTION ON THE GREAT LAKES.*

The following notes upon some features of crib construction for lake harbors are respectfully submitted in compliance with your direction, and are made without any claim that the points referred to are peculiar, and without any comment upon the relative merits of methods which differ.

These notes are based upon observations made during 28 consecutive years, of the works at Lake Ontario harbors (and for short periods of works on Lakes Erie and Champlain), some of which have been maintained since 18.9, some of which have been removed and some destroyed, and all of which have been repeatedly repaired and renewed.

These works for the formation and protection of harbors, were all originally formed of cribs of timber (usually hemlock) filled with fragments of loose stone, sunk separately but more or less closely in contact, upon the desired line of construction and then bonded together above water by continuous superstructure also formed of timber (usually white pine) framed and bolted together, filled with loose stone and decked with plank 3 ins. thick.

This superstructure has a height above mean water level varying from 2 and 4 ft. at the less exposed harbors to 11 ft. at Oswego Harbor, which latter place is considered by engineers having had extensive experience on the upper lakes and also at Oswego, to be exposed to destructive wave force not exceeded on the Great Lakes.

The conditions included by these various works therefore include maximum and minimum exposure, while the materials forming the natural bottom upon which the structures have been built have varied from loose sand to solid rock.

The point first attracting attention is the desirability of forming a riprap foundation in a dredged trench whenever soft or loose material is to be built upon. If made 3 ft. deep and 10 ft. wider than the crib on each side (the cribs being generally 20 ft.), this should cost about $4.50 per lin. ft. of pier. Different parts of the various piers have been built with and without this foundation, and comparison of results shows its advantage.

The best length of crib for the substructure is a vital point. The majority of the cribs, and nearly all of those prior to 1885, were limited to 30 or 35 ft. in length, this being the maximum length at which timbers could be had without extra cost. The result is that the small cribs settle irregularly, and that between the adjoining cribs are spaces varying from 1 in. to 2 ft. through which sand washes into the channel or harbor which the structure protects. Horns, shutters, vertical timbers, and various devices have been used to minimize this, but it is best if almost wholly avoided by building the separate cribs forming the substructure of the greatest length which can be handled safely. The only limit of length of each crib is the amount of stone which can be put afloat at one time and handled in one day to sink the crib safely in position. In one case a crib, designed by the writer to be placed in the most exposed location on the lake, was made 150 ft. long. To avoid chance of loss it was built water-tight, so as to float 1,200 tons of stone filling; it was safely sunk during a quiet day, between autumn storms, in half an hour on Nov. 18, 1889. The cost of making the crib water-tight did not exceed 1%, and was regarded as an insurance.

The bottoms or floors of the cribs have been made close and partly open, and open along the sides, and in all the various ways practicable. The economy of close bottoms securely tied to the upper part of the crib, so as to utilize all the weight which rests upon the floor, has been clearly proven.

The advantage of using screw bolts with nut and washers to fasten the crib together instead of drift bolts has been shown, vertical oak posts being used in combination with the screw bolts to fasten the face timbers to the ties and to each other and to the bottom, and to bond the corners of the crib together. This utilizes the tensile strength of the iron, which is about thirty-fold the frictional hold of the same size iron when it is used as a drift bolt. Unfinished work thus secured at an extremely exposed location has been left open at the contractor's risk through severe winter gales, which would have destroyed drift-bolted work, but which had no effect upon this, and other similar work equally exposed has stood nine years without any repairs.

Deck plank laid longitudinally and tight together has given the best results. When laid with air spaces between the planks the portion of the plank between the supports decays less rapidly, but upon the points of contact with the supporting joists or ties they decay as rapidly as when laid closely, while the air spaces give opportunity for the wave force to exert itself in tearing the planks from their fastenings. The spikes which fasten the deck plank are found to give the best results when of steel wire and of length sufficient to enter the pine deck supports 7 to 8 ins. It is important that the head of the spike should not be driven down so that the fibers of the wood are broken and depressed about them. To avoid early decay around the spike the head must be left just touching, but not buried into, the surface of the plank. Plank which had been fastened with square spikes, whose heads had been driven down into the wood, have repeatedly been found to be sound otherwise, but with a hole at every spike caused by decay resulting from water soaking into the bruised fiber.

Upon a lake which remains open all winter, as Ontario does, the erosion by floating ice is a most important force to be considered. Ten years' erosion will reduce pine timber 1½ to 2 ins. for a space of 2 ft. above and below the mean water line of the winter months. The use of steel plates or of oak timbers at this part of the work is desirable on the exposed faces, and will greatly prolong the life of the structure.

*Report of Assistant Engineer William Pierson Judson to Maj. W. S. Stanton, Corps of Engineers, U. S. A., in Annual Report of the Chief of Engineers, U. S. A., for 1896.

THE NEW SEDIMENTATION BASIN AND MASONRY COVERED SAND FILTER BEDS AT ALBANY, N. Y.

(With two-page plate.)

After suffering for a number of years from a notoriously bad water supply the city of Albany, N. Y., is about to construct the largest water purification plant in the United States.* Bids for this work are to be received until February 15. The work includes a sedimentation chamber with a capacity of 16,000,000 gallons; eight masonry-covered filter beds with an available area of about 0.7 acre each and a total daily capacity of 15,000,000 gallons, but expected to work at a lower average rate; a masonry-covered pure water reservoir with a capacity of 600,000 gallons; and all necessary appurtenances for a complete water purification plant, including devices for aerating the water before sedimentation, regulators to control the rate of filtration, a bacteriological laboratory and sand-washing apparatus. The largest sand filter bed plant now in use in the United States is the one at Lawrence, Mass., with a capacity of 5,000,000 gallons. The largest mechanical filter plant yet put in operation is at Wilkes-Barre, Pa., with a capacity of 10,000,000 gallons.* In point of population Albany is much larger than either of the two cities named. The largest city now having a water purification plant in operation is Atlanta, Ga., which had a population of about 66,000 in 1890, against about 95,000 in Albany the same year. Atlanta has a 7,000,000-gallon mechanical filter plant.

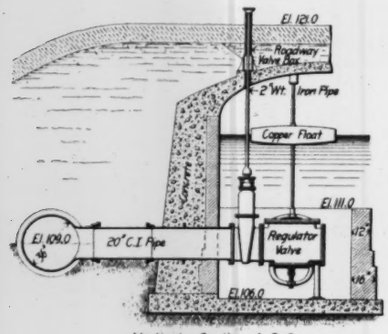
Albany has not accepted a bad water supply without vigorous protests and efforts in other directions. Its original supply was by gravity from small streams or ponds. In 1873 it was forced to supplement this supply by pumping from the Hudson River. About 1888, contracts were let for a driven well plant to have a daily capacity of 15,000,000 gallons. Some 400 wells, or more, were sunk, but the amount of water contracted for was not secured and the city refused to accept the wells. Subsequently it erected the pumps, intended for the driven well supply, at the Hudson

*The Lawrence plant was described in Engineering News of Aug. 3, 1893, and the Wilkes-Barre plant May 21, 1896.

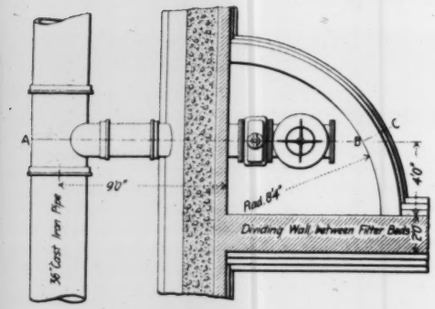
River pumping station. Since 1890, several plans for a gravity supply have been considered, with the idea of abandoning the Hudson River, but in 1897 the water commissioners adopted a report by Mr. Allen Hazen, Assoc. M. Am. Soc. C. E., St. Paul Building, New York, recommending the purification of the Hudson River supply by the means outlined above. The report was approved by the city council and steps taken to carry it into execution. The gravity sources, yielding an average of, perhaps, 5,000,000 gallons a day, are to be continued in use.

The present Hudson River intake is located near the heart of the city. A number of sewers discharge into the river above the intake. The new intake and purification plant will be located further up the river, just above what is known as the lumber district. Water will be pumped to the sedimentation basin and after filtration will flow by gravity from the pure water reservoir to the present pumping station.

The general plan of the new purification works is shown by Fig. 1, on our two-page plate. The



Vertical Section A-B-C



Sectional Plan

Fig. 6.—Inlet to Filter Beds, Albany, N. Y.

pipe system is shown by Fig. 2. Fig. 3 shows a partial plan and section of Filter Bed No. 1 and Fig. 4 shows, by means of sections on a larger scale, how the beds are covered with groined arches of concrete.

Water is to be pumped to the sedimentation basin, reaching it through a series of vertical inlet pipes along the river side of the basin. The inlet pipes are to be pierced with small holes near their upper ends through which the water will be forced in small jets, about 206 jets to each pipe, thus affording aeration. These inlet pipes are shown in the plans, Figs. 1 and 2, and in the section through the embankment of the basin, Fig. 5. This figure also shows the outlet from the sedimentation basin to the filters. These outlets connect with the main supply pipe to the filters. The water is admitted to the several filters through inlets at the corner of each bed, as shown in the plans, Figs. 1, 2 and 3, and in the detail, Fig. 6, herewith. The filtered water is to be collected by a system of 6-in. drains at the bottom of each bed, as shown in the plans, Figs. 2 and 3, after which it will pass through the regulator house to the large central pipe leading to the pure water reservoir. The details of the regulator chamber are shown by Fig. 7. Overflow chambers are provided for each bed, being located between the sand runs. These chambers are shown in detail by Fig. 8.

The underdrains are to be of 6-in. vitrified salt-glazed pipes, in 2-ft. lengths, with the bells cut away at the lower side, "so that the barrel of pipe will rest its entire length on the concrete floor." The underdrains are to be laid with open joints, about ¾ ins., to be "left between the barrels of each two pipes for the admission of water."

The maximum depth of the filtering material will be 5 ft., of which there will be a uniform depth of 4 ft. of sand, the balance being of gravel or broken stone. The specifications for the filtering material are as follows:

Filter Gravel.

On the floor of the filters and surrounding the underdrains shall be placed gravel or broken stone having a maximum depth of 1 ft. Instructions shall be given by the engineer as to the exact arrangement and positions of the various layers when the stone commences to be received upon the ground, but the arrangement will be approximately as follows: The lower 7 ins. shall consist of broken stone or gravel, which will remain upon a screen with a mesh of 1 in., and which has but very few stones over 2 ins. in diameter. Above this shall be placed 2½ ins. of broken stone or gravel which has passed a screen with a mesh of 1 in., and which remains upon a screen with a clear mesh of ⅜-in., and above this shall be placed 2½ ins. of broken stone or gravel, which has passed a screen with a mesh of ⅜-in., and which is coarser than the ordinary sand, and entirely free from fine material. The exact depth of the various layers and the meshes of the various screens may be varied somewhat, and the contractor will be allowed to make such reasonable changes as will allow the material to be handled economically and to the best advantage, but before making any changes he shall consult with the engineer, and no change shall be allowed which will in any way interfere with the efficiency of the filter.

Gravel shall not be placed within 6 ft. of the inlet or outlet chambers, nor within 2 ft. of the outside or cross-walls, these spaces being reserved for filling with sand.

In case the gravel used for the lower layers should contain any material so fine that pieces might enter the joints of the drain pipe, the engineer may order coarser material to be selected from the gravel or broken stone and to be placed about the joints, the quantity of such material not to exceed 1 cu. ft. per joint.

The gravel for all of the layers may be broken trap rock screened to the proper sizes, or gravel screened from sand and gravel banks of a sandy nature. Gravel screened from hard pan or clayey material cannot be sufficiently cleaned. The gravel shall not contain more than a very small amount of shale or limestone. The gravel shall be washed entirely free from fine material, so that water passing through it or agitated in contact with it will remain substantially clean. No dirt or foreign matters of any kind shall be allowed to enter the filters after beginning to place the gravel, and any gravel made dirty in any way after placing shall be at once removed and replaced to the satisfaction of the engineer.

The price bid per cubic yard for filter gravel includes the screening, washing and placing of all the different grades above enumerated, no deduction being made for the space occupied by the underdrains.

Filter Sand in Place.

The filter sand shall be clean river, beach or bank sand, with either sharp or rounded grains. It shall be entirely free from clay, dust or organic impurities, and shall, if necessary, be washed to remove such materials from it. The grains shall, all of them, be of hard material which will not disintegrate, and shall be of the following diameters: Not more than 1%, by weight, less than 0.13 mm., nor more than 10% less than 0.27 mm.; at least 10%, by weight, shall be less than 0.36 mm., and at least 70%, by weight, shall be less than 1 mm., and no particles shall be more than 5 mm. in diameter. The diameters of said grains will be computed as the diameters of spheres of equal volumes. The sand shall not contain more than 2%, by weight, of lime and magnesia taken together and calculated as carbonates. In all other respects the sand shall be of a quality satisfactory to the engineer. The contractor shall take adequate precautions to prevent foreign or polluting material from becoming mixed with the sand, and shall protect the sand from such material until the filters are put in operation.

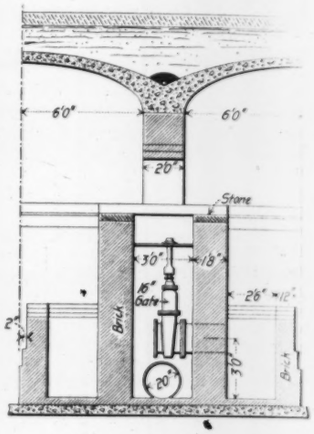
Samples of sand fulfilling the above requirements may be seen in the offices of the engineer, and he will examine samples of sand submitted by intending bidders and advise them whether or not they are suitable.

The filter sand shall be placed in the filters in four layers, each layer to be about 1 ft. thick, and the sand shall not be dropped from a height into final position or otherwise unduly compacted. The three first layers may be filled in to only approximate depths and the surfaces need not be smoothed. The final layer shall be brought to a true and even grade, and the surface left smooth and uniform, and such allowance shall be made for settlement as the engineer may direct.

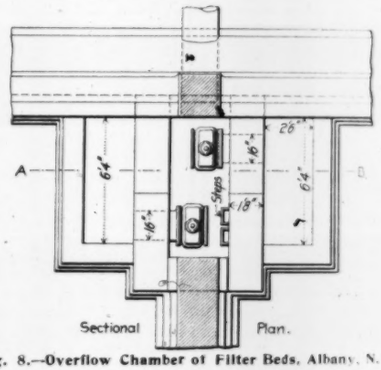
The price bid per cubic yard for filter sand includes securing, transporting and placing the sand, together with all screening, washing or other cleaning which may be necessary to make it conform to the above requirements, and the final measurement shall be made in place after settling one week with water and with the filters in operation.

The concrete floor of the sedimentation basin is to be cut into squares of about 50 sq. ft., or of such size as directed by the engineer, by suitable metal forms extending partly or entirely through the concrete, and the openings thus left shall be entirely filled with an asphaltic mixture remaining soft at freezing temperature and satisfactory to the engineer.

The ventilator openings to the filter beds are each to be provided with two sheet steel covers, the lower cover being ⅛-in thick and provided with a suitable handle for raising it; the upper cover being ¼-in. thick and provided at the edge with a small opening for inserting a tool for



Vertical Section A-B.



Sectional Plan.

Fig. 8.—Overflow Chamber of Filter Beds, Albany, N. Y.

raising. These plates shall be painted with three coats of Smith's Durable Metal Coating or other paint satisfactory to the engineer.

When the beds are scraped the sand removed will be shovelled into wheelbarrows and wheeled out through the sand runs indicated on the plans and shown in section by Fig. 9. It will be deposited in one of the two sand-washers located in the depressed central court. The details of the washers are shown by Fig. 10, from which it will be seen that by means of ejectors the dirty sand will be forced through a series of hoppers connected by wooden troughs. The clean sand will be deposited in the sand box at the end of the apparatus and the wash water will run to the drain.

This article and illustrations have been prepared from the contract plans and specifications now on file in Mr. Hazen's office.

MINE HAULAGE BY COMPRESSED AIR.

Compressed air has marked advantages over any other class of haulage, in that it is free to go wherever there is a track laid; the distance run with one charge of air is only limited by the capacity of the motor tanks. Great advancement has been made in the improvements of com-

*Abstract of a paper read by Mr. E. P. Lord, superintendent of H. K. Porter & Co., Pittsburg, Pa., before the Anthracite Coal Operators' Association in New York city. The complete paper is published in the "Bulletin of the Association," which can be obtained of the Secretary of the Association, Mr. Henry S. Fleming, 26 Cortlandt St., New York city.

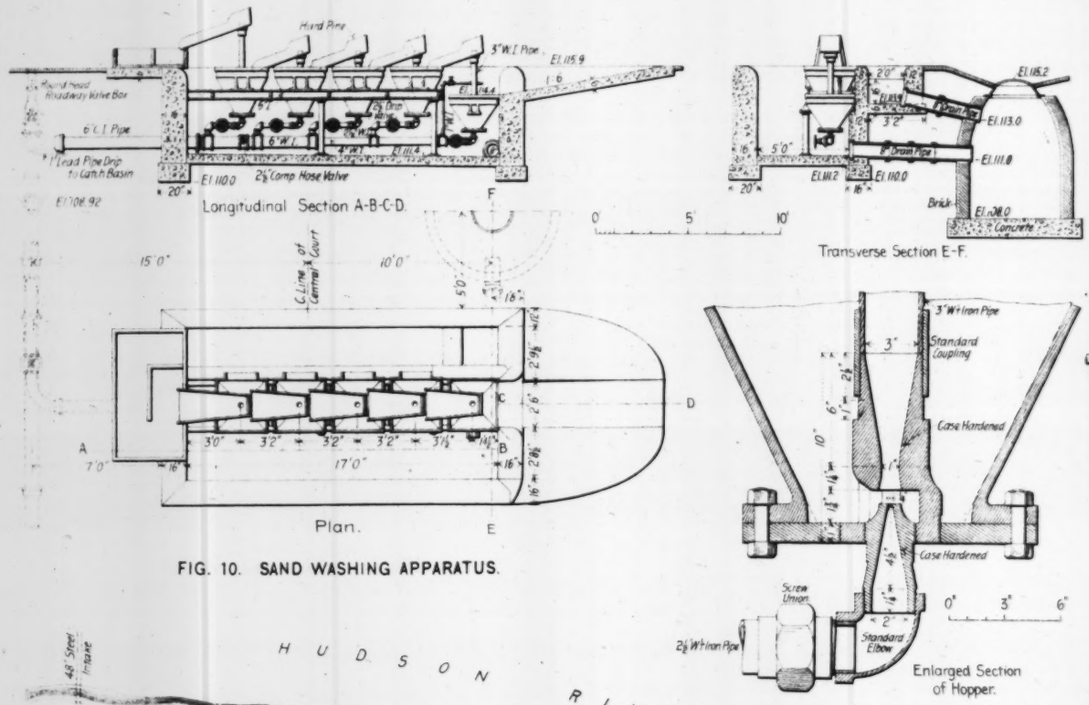


FIG. 10. SAND WASHING APPARATUS.

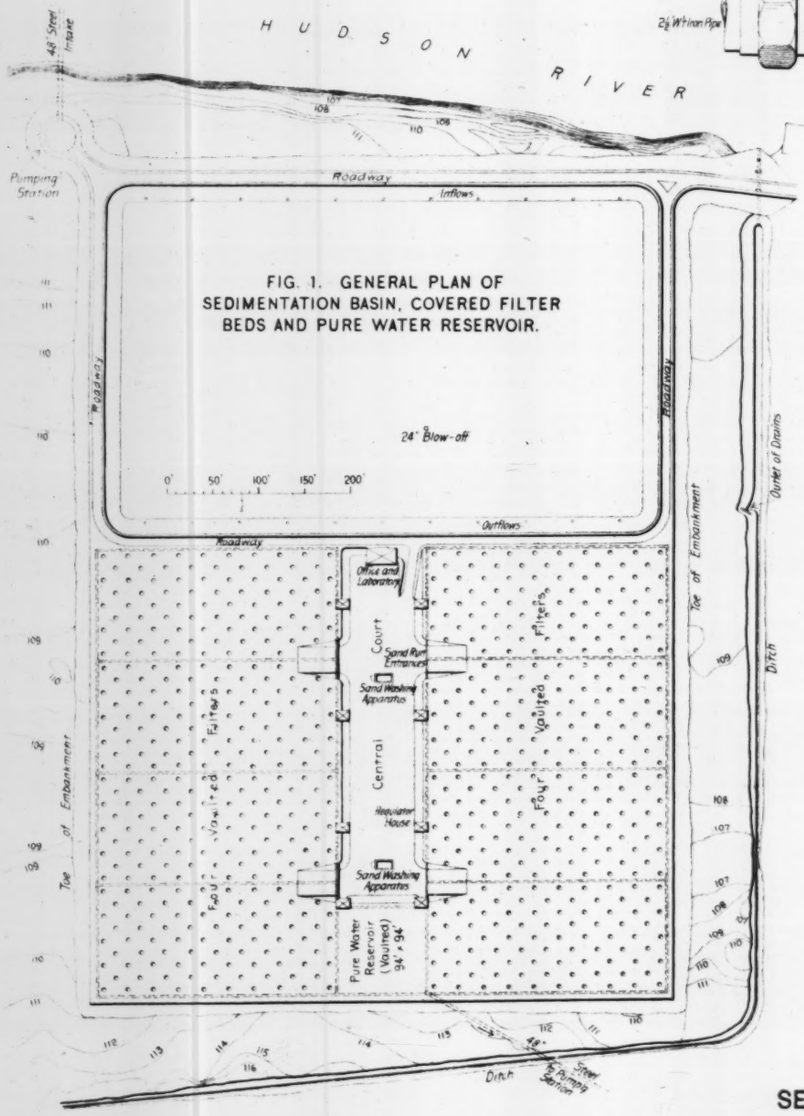


FIG. 1. GENERAL PLAN OF SEDIMENTATION BASIN, COVERED FILTER BEDS AND PURE WATER RESERVOIR.

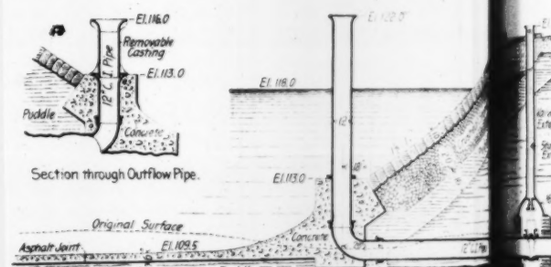


FIG. 5. SECTION THROUGH EAST BA

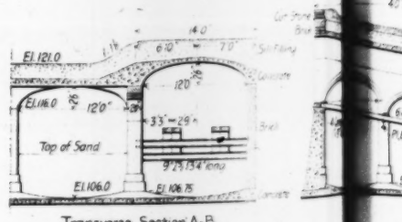
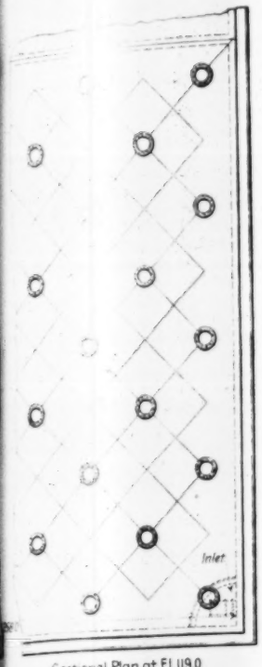
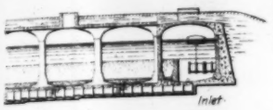


FIG. 9. SECT OF SA

SEDIMENTATION BASIN, COVERED FILTER BED AND

Allen Hazen, Assoc. M. Am. Soc. C. E., Chief Engineer, New York City; Geo. I. Bailey, S inter





Section.

ON OF ONE FILTER BED.

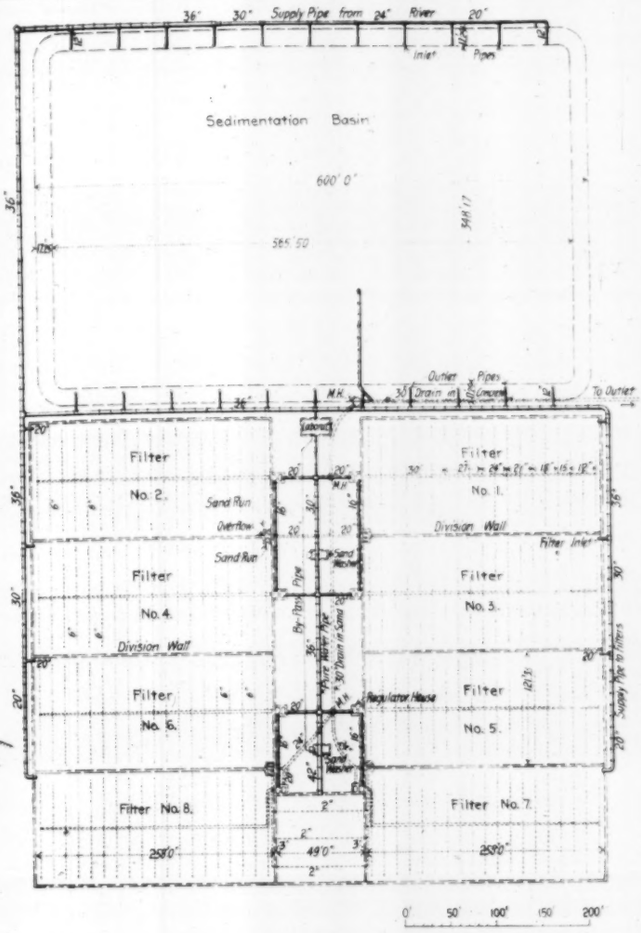
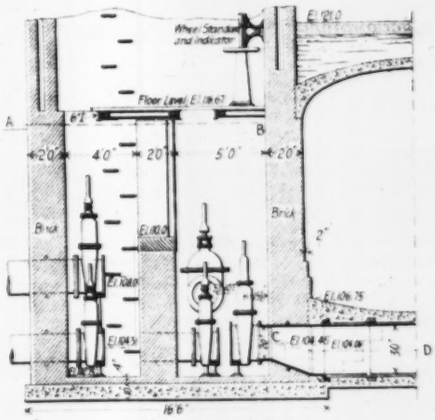


FIG. 2. DISTRIBUTING AND COLLECTING PIPE SYSTEMS.



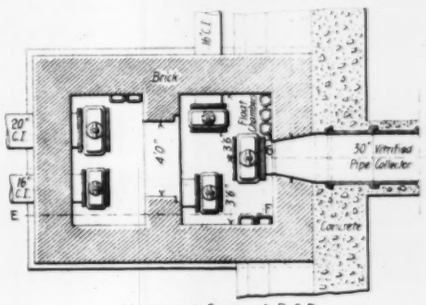
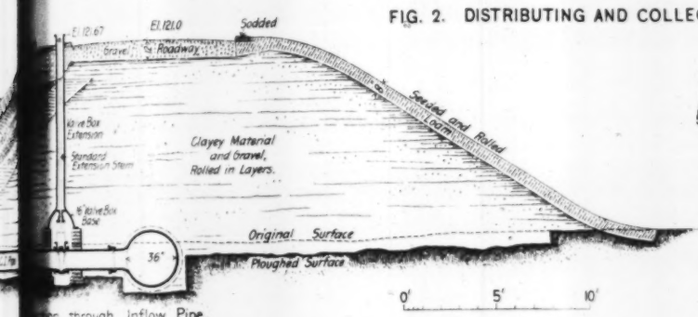
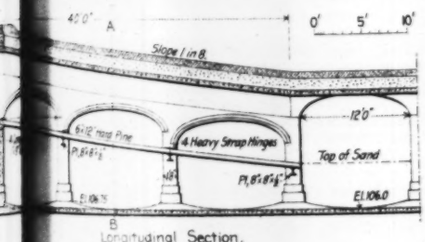


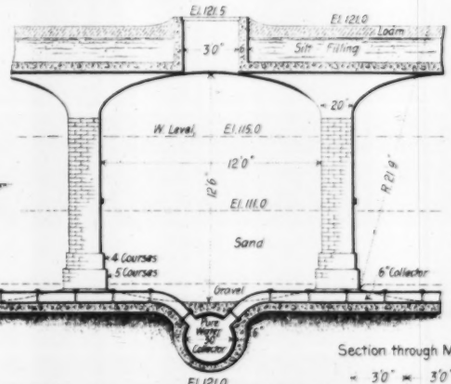
FIG. 7. REGULATOR CHAMBER.



EDIMENTATION BASIN, INLET PIPE AND OUTLET PIPE.



OF SAND RUN.



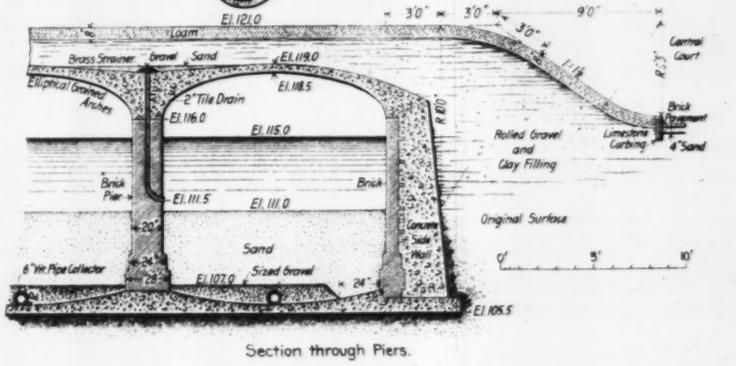


FIG. 4. SECTIONS OF FILTER BEDS.

ND PURE WATER RESERVOIR, ALBANY, N. Y.

intende Water-Works; **Vreeland H. Youngman, Chairman Construction Committee.**

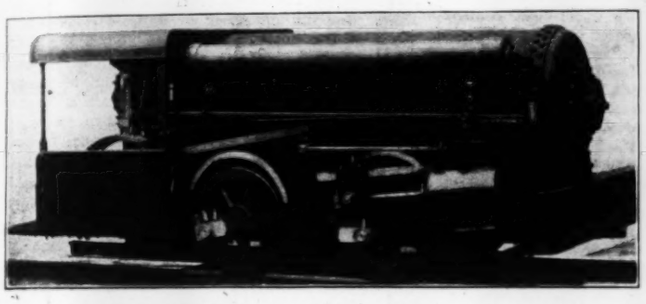
CHAS. HART & SONS, LITH. 34 VESEY ST., N. Y.

pressors, pipe lines, pipe connections, motors, methods of charging, etc.; so that for efficiency it is admitted that compressed air runs electricity very close for a long-distance transmission. It is equally efficient and safe in fiery and non-fiery mines, and materially assists ventilation by the air given out by the exhaust. Efficient ventilation must be provided for, in any case; but compressed air is now used for driving mining machines in rooms or in butt entries ahead of the general work and beyond the range of general ventilation.

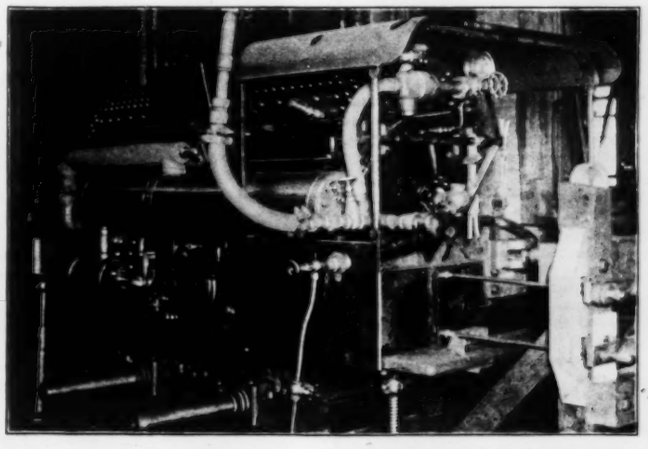
Compressed air recommends itself also for many other practical advantages, such as moderate cost of plant and installation, due to the absence of overhead wires or obstructions; economy of operation, secured by durability of construction; convenience and simplicity of operating and management; minimum risk of delay from breakdown or derangement; exceptionably low cost of maintenance; safety, due to the large factor of safety of all parts subject to strain, and the practical impossibility of over-charging; the absolute absence of fire, thereby enabling it to be used without risk, where steam or electricity is equally objectionable; cleanliness and quietness with which it can be operated, and flexibility, adapting it to almost any requirements. Again, it can be adapted to any varying requirements of service, so that the entire plant can be run economically at only a fraction of its full capacity, no more power being generated than is needed for the work to be done.

Compressed air locomotives are designed and constructed for a very wide range of service. Some of the principal uses are as follows:

Underground haulage in mines, whether worked by shafts or slopes, hauling trains through tunnels and city streets, transporting material at industrial establishments; also in various manufactories of an extra hazardous nature, where there are any special fire risks; general haulage, where fuel is expensive and water power available; street railways in large cities.



COMPRESSED AIR LOCOMOTIVE FOR PEERLESS COAL & COKE CO., VIVIAN, W. VA.



COMPRESSED AIR LOCOMOTIVE FOR THE ANACONDA COPPER MINING CO. (On Testing Stand in the Shops of H. K. Porter & Co.)

The air for mine locomotives is stored in one or two steel tanks having a cubic capacity designed for the length of run, weight of train, grades, etc. These tanks usually occupy the space that the ordinary boiler does on the steam mine locomotive. They are constructed with a large factor of safety, and are tested to a much higher working pressure than they are designed to carry. The air from the main tank or tanks is conducted through copper pipe connections to an auxiliary reservoir of suitable diameter. The pressure in this auxiliary tank can be regulated (usually 150 pounds) anywhere from 30 up to 300 lbs., as required. The air is reduced and controlled from the main tanks by a reducing valve and stop valve, which can be regulated to any pressure at a moment's notice; and when once set, maintains a constant, fixed pressure (usually 150 lbs.) in the auxiliary reservoir, thereby preventing any undue waste of air, unnecessary slipping of driving wheels, etc., by injudicious handling. In case only light loads are to be handled, the pressure can be materially reduced in the auxiliary reservoir. On the other hand, in emergencies the higher pressures can be at a moment's notice utilized. In the auxiliary reservoir the air is controlled and delivered to the cylinders by a differential throttle valve. The port openings in the cylinders are specially designed for the use of air, and there is absolutely no back pressure in the cylinders, no matter at what load the engine is working, and no trouble is ever experienced from the freezing of the exhaust.

The actual cost of operating the first plant we installed in the Anthracite region was found to vary from 1 to 1¼ cts. per ton, mile net weight hauled, including all expenses, interest and depreciation of plant. The saving by the use of compressed air over mule haulage being equal to the entire cost of plant in 2¼ years, averaging 204 working days each, one locomotive being used to only one-half its capacity, and the other about one-fifth of its capacity. To operate both motors to their full capacity, and also the compressor, would add very little to the steam, lubrication, repairs, etc., but would reduce the cost of operating even below these figures.

In installing a compressed air plant the most important items of installation are the boilers, compressor, pipe line, charging station and motor. The size and capacity of these various units depend upon the physical characteristics of the mine and the required output in tons of coal per day. Upon the number of times that the motor is to receive a full charge of air per hour, is based the capacity of the compressor, while the pipe line serves as a storage reservoir for storing up air while the motor is in service. The pipe line should be of such diameter and length as will give a cubic capacity of air at a certain pressure, sufficient to equalize immediately in the tanks of the motor when connection by couplings is made. In the old principle of installation pipe lines were not generally used, but large, expensive air receivers were substituted, and the motor generally took its charge of air from them direct and then made its round trip. In all plants we recommend the laying of pipe lines of a certain cubic capacity; the size and length of pipe depending largely upon what points in the mine it is necessary to reach in order to arrange charging stations so that the motor can conveniently receive its charge of air without any delay.

There is an erroneous idea that considerable time is lost in charging a compressed air locomotive; while in fact the largest motors which we have constructed can be brought to a standstill, the couplings made and broken, and the full charge of air received in a minute to a minute and a half.

Below is a list of a few of the different types of compressed air locomotives which we have designed and installed.

Two 7 × 14, class B motors, Susquehanna Coal Co.; 5 ft. 3 ins. wheel base, 36 ins. gage, 130 cu. ft. capacity of motor tanks; weight in running order, 18,500 lbs.; length over all, 17 ft. 6 ins.; width, 5 ft. 2 ins.; height, 5 ft.; working pressure, 600 lbs. This locomotive hauled a trip of 16 empty cars (about 2,500 lbs.) from foot of shaft, 3,700 ft. into gangway, and trips of 16 loaded cars (each with about 6,700 lbs. of coal), back to the shaft, with one charge of air; starting with a pressure of 575 lbs., and ending with a little over 100 lbs. The heaviest work is hauling empty trips up grade. Average grade, 1.07%; maximum grade, 2.8%, in favor of loads. The weight of each empty trip with 16 cars, including locomotive, is about 60,000 lbs.; and of a loaded trip, including locomotive, 166,000 lbs. This locomotive makes from 25 to 50 miles per day, depending upon the length of the run and the time required for making up trips. At 20 trips per day, the output amounts to about 1,070 tons, and with one motor. Approximate cost of such a plant, all complete, $12,000 to $14,000. This includes cost of compressor house and foundations and material for same; all steam connections; 6,000 ft. of 5-in. pipe, 4,000 ft. of 3-in. pipe; compressor and two locomotives.

We have recently completed for the Rochester & Pittsburg Coal & Iron Co. two 9½ × 14 class C locomotives, having 5 ft. 6 ins. wheel base; 6 drivers, 26 ins. diameter; weight, 28,000 lbs. in working order; capacity of the two motor tanks, 187 cu. ft. of air at 600 lbs. maximum pressure; height, 5 ft. 3¾ ins.; width over front bumper, 74 ins. for 42-in. gage; width over tanks, 72 ins.; length over bumpers, 19 ft. 5¼ ins. These locomotives are designed to run on 30 and 35 ft. radius curves, and are to run on a 25-lb. rail, which they can do very safely. Where the rails are light we recommend a six-wheel type. The locomotives are of our recent design, and have given exceptionally satisfactory results. They are running a distance of 6,000 ft. on butt headings, or 12,000 ft., round trip, with one charge of air. They are hauling over a 4% grade with empties weighing 1,600 lbs. each, and 22 to 28 cars per train; cars holding about 2 tons each. Total weight loaded train including locomotive, 92 tons. The first locomotive we built for these people, in 1892—a very crude machine compared to our present design—runs 5,900 ft. from place of charging, with empties, and return with loads, making round trip of 11,000 ft. with one charge of air and hauling 22 cars each way.

We have also completed the installation of a number of plants in the anthracite territory, notably, two 7 × 14 class B motors, for the Mill Creek Coal Co.; one 10½ × 14 for the Cross Creek Coal Co., Drifton, Pa. Plants recently completed in the bituminous districts are, one 8 × 14 class B motor for the Mount Carbon Co., West Virginia; and the Carbon Coal Co., Greensburg, Pa., one 8 × 14 class C motor.

We built a 5 × 10 class B motor for a large copper mining company in Montana, which had a 3-ft. wheel base, and designed to run on curves of 12 ft. radius; for 18-in. gage; four drivers, 23 ins. in diameter; weight in working order, about 10,000 lbs.; 47 cu. ft. of air, 550 lbs.; height, 58 ins.; width, 58 ins. over cab; length over bumpers, 10 ft. 4½ ins. This motor was equipped with a re-heater, and we made a special test of the same in our shops in order to ascertain the relative efficiencies when working under cold and hot air.

The economies of compressed air haulage are best obtained by using the air expansively in the cylinders. The tendency is usually to work a motor up to its highest practical capacity, allowing the air to follow the piston the greater part of the stroke. This means decreased expansion in the motor cylinders and less efficiency than could be obtained with larger cylinders and greater expansion of the air. It is very essential that the total weight of the motor in working order should be somewhat in excess of what is the general custom with steam locomotives, inasmuch as there is always at hand a higher pressure than the working pressure, which can be utilized, provided a fair margin has been allowed for weight on drivers. It is our custom to make our engines considerably heavier than is ordinarily followed in locomotive construction generally. Not only does the frictional resistance of mine cars frequently run extremely high, but greasy and wet rails, poor line and surface are disadvantages which very largely contribute to the slipping of locomotive drivers, and emphasize the great importance of not depending upon too low a coefficient for weight of motor to tractive force of same. For best results we have assumed that the tractive force must be equivalent to one-fifth the weight of the motor.

Size of Motor and Energy Required for Stated Trains and Length of Run.

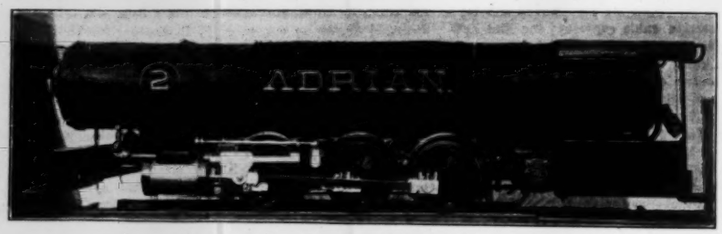
In order to determine the proper size of motor, and tank capacity for the same, it is in most cases necessary to figure out the energy required in foot-pounds for doing the work. The factors entering into this calculation are: (1) Frictional resistance—usually 20 to 40 lbs. per ton, depending upon the condition of track and rolling stock; (2) Grade resistance—20 lbs. per ton for each 1% of grade; (3) the curve resistance, depending upon the length and sharpness of curves; (4) weight of empties and weight of load; daily output in given pounds, and most desirable size of train.

Having determined the weight of train, the daily output and the severest conditions of grade, etc., the size of motor required, the next point to determine is the size of store-tanks on motor, sufficient for making certain round trips between charging points with one charge of air. In order to make a correct estimate we should know the grades and conditions for each varying section of track.

For mine service there are few motors at present built for a pressure higher than 700 lbs. per sq. in. When long runs are necessary between charging points—say, 1½ to 2 miles

it becomes necessary for the usual size of mine motors to carry a higher pressure in the motor tanks, say 750 to 800 lbs.

In connection with these higher pressures, it is often possible to heat the air, in order to obtain the greatest possible work from them. This heating can be done either by direct heater, or by injecting steam into the auxiliary tank while the motor is being charged with air. When the auxiliary tank is employed as a heater, it is from a half to two-thirds full of hot water and steam, and the air made to pass through the same on its way to the throttle and cylinders. Again, the moisture taken up by the air when heated by hot water helps materially to lubricate the cylinders and valve surfaces. If air at normal temperature in a pipe line is re-heated, and thereby expanded, the additional volume of air resulting from the expansion is produced by an expenditure of heat much lower than the original volume of air was compressed for, and by a much lower expenditure of heat than is required to produce an equal volume of steam.



THREE-DRIVER TYPE OF COMPRESSED AIR LOCOMOTIVE.

Pipe Lines.

Frictional resistances in pipes conveying fluid are proportional to the density of the fluid; consequently, at equal velocities, the frictional resistance of air is enormously less than that of water. Air may be transmitted in mains, without serious loss or fall of pressure, at ten to twenty times the velocity practicable with water in water mains. Air at 90 lbs. is 115 times lighter than water, and frictional resistance at equal velocities is less than 1% of that of water. In air mains velocities of 25 to 50 ft. per second are allowed without serious frictional loss. In consequence of this high velocity, large amounts of air power can be transmitted by air at moderate pressures in pipes of moderate dimensions.

In the installations we have made, we have never found it necessary to recommend anything above 6 ins. in diameter; 5 ins. has been the size of pipe most utilized, and as low as 2 and 3 ins. We have found that in pipe lines of a mile or over, the difference in pressure at both ends has been hardly appreciable.

Compressors.

Where the air is to be compressed to the high pressures necessary to pneumatic haulage installations, we recommend the use of the compound principle of compression. Single compressors have an increasing resistance with the advance of the piston, and increasing temperature of the air, and it is quite necessary to equalize in some manner this vast difference in pressure. The compound compressor secures more uniform resistance at all points of the stroke, and is by far the most economical and efficient machine for mine service.

In the test made of the compressed air installation of the Susquehanna Coal Co., the air from the three-stage compressor—taking air from the atmosphere and compressing it to 600 lbs.—was only 180° at the point of discharge. This shows the manifest benefits of compounding and proper intercooling. Some of the best designed three-stage compressors, compressing to 2,200 lbs. pressure, the air, after undergoing the three stages of compression, shows a final temperature after leaving the last or high pressure cylinder of 336°; this with the temperature of the intake air at 60°.

There has been some little discussion going on of late on the subject of explosions and fires in air compressing engines and air receivers. In every case the cause of explosion or ignition is unquestionably due to an increase of temperature above the flash point of the oil which is used to lubricate the compressor. Thin oil, with high flash point, and as free from carbon as is consistent with good quality, should be used. We believe that the cases that have occurred in general practice have been wholly confined to the single acting compressors, and not the compound type. If compound compression was specified for all mine pressures above 60 lbs., the result would be low temperatures and better results. Some of the trouble may be traced to a manifest increase in the temperature of the incoming air, which is made excessive by the sticking of one or more of the discharge valves, thereby allowing some of the hot compressed air to flow back into the cylinder, and in that manner influencing the temperature before compression. It has been pointed out that the discharge passages or discharge pipes in course of time will accumulate a deposit of carbon from the oil, which will so constrict the passages that the volume of air delivered to the compressor is much impeded.

Efficiencies.

By the word "efficiency" we mean the percentage which the power given out by the motor bears to the power required to compress the air in the compressor. The ultimate power developed at the motor is frequently a small percentage of the power expended. In many cases the losses are due to poor designing and faulty installation, and cannot be directly charged to faults of the system or bad workmanship. If we were to make a careful test of a compressed air mine plant, including the indicating of the pumps, hoisting engines, drills, etc., we might be surprised at the low horse-power resulting, as compared to the indicated horse-power of the compressor. We might arrive at an efficiency as low as 25% to 35%, which would perhaps appear unfavorable and misleading, did we not take into consideration the manner in which the power is used. Indicator diagrams from almost all the pumps in use would take the form of a perfect parallelogram, with a terminal pressure equal to the initial pressure. This condition of things is also true in the hoisting engines or drills. Of course, these machines would use steam under the same wasteful conditions, and would show a correspondingly poor efficiency if compared with the same volume of steam used expansively in an economical engine. The air locomotive uses the air expansively, and its efficiency is correspondingly increased.

As regards the losses that are frequently chargeable to a compressed air plant, one compressor builder very concisely expresses them as follows:

1st.—Friction of compressor—amounting ordinarily to 15 or 20%; never probably reduced below 10%. 2d.—Loss occasioned by pumping air drawn from the engine room instead of from the outside or some other cooler place. This loss varies with the seasons, the amounts varying from 3 to 10%. This can all be saved. 3d.—Serious losses arise in the compressing cylinder. Insufficient supply, difficult discharge, defective cooling arrangements, poor lubrication, and no end of other causes perplex the designer and rob the owner of power. The fourth loss is found in the pipe line. No leak can be too small to require immediate attention.

By adopting recent designs, with all the latest improvements, the cubic feet of air compressed per hour per horse-power has been raised from 264 to 367—a decided advance. The power can be transmitted, say at a pressure of 60 lbs., to two miles distance with an efficiency of 50% on the indicated horse-power of the compressor engine; this without reheating. By heating the air this efficiency may be raised to 70%.

Pneumatic motors under most adverse conditions have been able to show efficiencies between 30 and 40% with cold air.

When it is understood that compressed air motors carrying 600 to 750 lbs. of air can run a distance of from a mile and a half to three miles, according to physical conditions of mine, and with one charge of air, the question is often asked why higher pressures cannot be used with economy, so that the motor may never require to charge except at one most convenient point in the mine system. If we were to resort to higher pressures, say 1,500 to 2,500 lbs., we would have to substitute Mannesmann tubing for the tanks at present constructed. This means much increased cost, as the price of this tubing, now made only in Germany, is very high. And again, a proper storage system, either in pipe line or receivers, would be necessary in order to charge the motor promptly. Therefore there would be no saving in cost of installation. Where the height of entry is limited, high pressure motors as above could be used advantageously, but at an increase in first cost. They could be constructed to meet the same limited heights as electric motors.

OPERATION OF THE OCEAN OUTFALL SEWER AT LOS ANGELES, CAL.

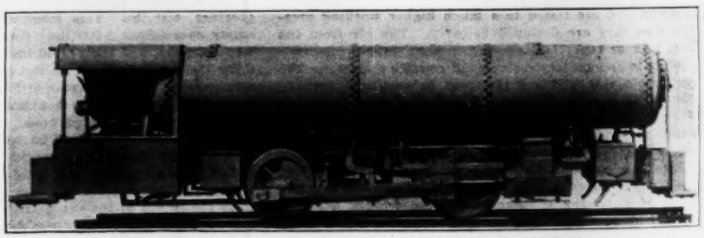
In our issue of Feb. 28, 1895, there appeared a long, illustrated article by Mr. Burr Bassell, describing the new sewerage system of Los Angeles. During the past year Mr. Bassell read a paper before the Technical Society of the Pacific Coast, in which the sewerage system is described and an account is given of the operations of the outfall sewer and the experience with handling sewage for irrigation.* A few of the most significant new ideas brought out by the paper are given below:

The outfall sewer is 12.4 miles long, being partly a brick conduit from 40 to 52 ins. in diameter, partly in tunnel and including two inverted siphons, each about three miles long, of 38-in. wood stave pipe. The ocean end of the outlet consists of 1,200 ft. of 24-in. flanged cast-iron pipe, extending originally 600 ft. into the sea, unprotected from wave or current action. This submerged section has been shifted 15 ft. out of alinement, causing it to break about 100 ft. from low water mark. The sewage cut out a large basin at this break, which has encroached upon the bluff. Length after length of pipe dropped into the basin. As a temporary measure a flume has been built to again carry the sewage some distance out. Some ¾-in iron rods used in launching the submerged pipe have been entirely rusted and worn away; some of the flange bolts have entirely disappeared; and the rubber between the flanges has hardened.

The settling chamber or sand catcher at the head of the outlet sewer, lets "much the larger portion" of the sand in the sewage pass on to the sea, as predicted by Mr. Bassell in his article three years ago. It does serve as a rubbish chamber, and has been made to act as an "emergency waste way and point of divergence for sewage irrigation." A horizontal screen in the chamber has been abandoned and a vertical screen inserted.

The blow-offs provided on the line of one of the siphons had never been used up to the time Mr. Bassell wrote his paper last year, and are held by some to be useless. The bell-mouthed irrigating hydrants have been encased in a wooden box with an outlet connecting with the irrigating ditches.

Mr. Bassell states that during the construction of the outfall sewer he was asked to design a drop chamber, and on making it 12 ft. long, the objection was raised that it was unnecessarily large. He proceeds as follows:



COMPRESSED AIR LOCOMOTIVE FOR SUSQUEHANNA COAL CO., NANTICOKE, PA.

The writer maintains that the mean velocity of approach should not be made the governing factor in determining the path of the jet, and that the graphical method, usually employed in such cases, showing parabolic curves, is incorrect. * * * Having observed the flow at this drop when the sewer was carrying only 10 sec.-ft., or less than one-third its full capacity, and that the overfall strikes the toe of the opposite wall even with a vertical drop of 10.61 ft. (not including water cushion), he is confirmed in his statement, and thinks the mathematicians should revise their figures.

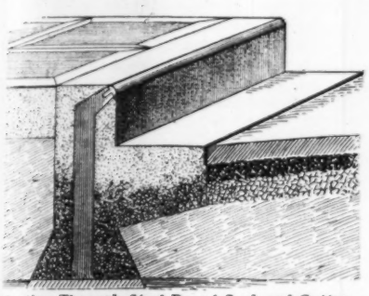
The straightway valves in use have given good satisfaction. It was found impossible to shut off the entire flow with the butterfly valves and one of these has been removed, "owing to the accidental twisting off of the valve-stem."

*This paper was published in the Journal of the Association of Engineering Societies for August, 1897. Mr. John C. Trautwine, Jr., 257 S. Fourth St., Philadelphia, is Secretary of the association.

A CONCRETE STEEL-BOUND CURB.

The accompanying illustration shows a section through a new form of curbing, which is here combined with a gutter, but need not be unless so desired. The curb is of concrete, protected by a T-shaped strip of galvanized steel. The outer edge of the gutter is also protected by steel.

The curbs can be made of any desired dimensions, but the one illustrated is 6 ins. wide and 6 ins. high, with a gutter 10 ins. wide. The steel curb strip is 2⅛ ins. across and 2¼ ins. deep. It is made in lengths of 20 ft., and is anchored at the end of each strip by means of iron posts about 2 ins. wide and ⅜-in. thick, with bases, as shown in the illustration. The gutter strip is a flat piece



Section Through Steel Bound Curb and Gutter.

of steel for asphalt work, but in macadam an L-shaped strip is used, with the base extending into the concrete for anchorage.

The steel binding strip can also be used for steps and other edges or corners exposed to wear.

This form of curb was patented in 1890, and again in 1897, and two more patents are now pending. It is reported by the manufacturers as having been in use in Washington, D. C., for five years, and as about to be introduced in a number of cities in the Eastern States. It is claimed that the curb can be put in at a price which will show a considerable saving over cost of dressed stone curb, but no contract figures are cited in support of this statement.

It is claimed that for use in asphalt-paved streets the concrete gutter is highly advantageous, being cheaper than the asphalt that it displaces, in first cost, and far more durable, owing to the well-known tendency of asphalt to fail at the gutter line. Obviously the curb in a street paved with this material can be brought to a practically perfect grade and alinement, and the manufacturers claim permanency in this respect. They also claim that the curb will not chip or break like curbs of stone or other material.

The curb is made under the trade name of the "Kosmocrete" steel-bound curb, by the Wilson & Baillie Manufacturing Co., whose main office and factory is at 85 to 93 Ninth St., Brooklyn. The company also has an office at 45 Broadway, New York city. For the above information we are indebted to Mr. C. B. Johnson, President, and to Mr. H. A. Miner, Solicitor of the company.

A FIRE STREAM DIAGRAM.

By Ernest Stenger, Assoc. M. Am. Soc. C. E.*

The accompanying diagram relating to fire streams is based on the experiments of Mr. J. R. Freeman, M. Am. Soc. C. E., as set forth in the Transactions of the American Society of Civil Engineers for November, 1889. The possibility of making one table suffice for several or more kinds of nozzles is due to the application of the fact that the discharging capacity of a nozzle can for practical purposes be stated in lengths of hose. Thus approximately 500 ft. of ordinary best quality 2½-in. rubber-lined hose is equivalent to a 1-in. smooth nozzle, so far as the discharge is concerned. In the same way, 300 ft. of hose is approximately equal to 1⅛-in. smooth nozzle, and 200 ft. is approximately equal to a 1¼-in. smooth nozzle. The equivalents of ring nozzles and other sizes of smooth nozzles can readily be deduced, but it was not thought best to encumber a practical working diagram with too much information for which there is but little use.

If we consider 100 ft. of mill hose as equivalent to 200 ft. of the best quality of hose, which is true so far as friction loss is concerned, we find that the diagram gives the correct results for mill hose. In the same way it can be made to serve for unlined hose by considering 100 ft. of unlined hose equivalent to 230 ft. of hose of the best quality.

The static pressure at the base of the play pipe is found by tracing the radial line expressing the discharge in any case, to where it intersects the abscissa drawn through the zero of the nozzle under consideration. The length of this abscissa denotes the static pressure at the base of the play pipe. The figures opposite the ends of the radial lines give the heights of the streams which the various sizes of nozzles give with the discharge of the radial line there ending. It will be noticed that the table also gives discharges for open butts.

The hose equivalents were taken at even hundreds of feet, which they closely approach, rather than the more correct equivalents, since the diagram is thereby simplified without introducing material errors.

*Assistant City Engineer, Omaha, Neb.

THE CONNECTICUT AVENUE VIADUCT at Washington, D. C., the competitive designs for which were published in our issue of Jan. 27, will be built of concrete if the recommendations of the District Commissioners are adopted. In the report on the competition submitted to Congress by the Commissioners the reasons for awarding the first prize to the design of Mr. Geo. S. Morison are given as follows:

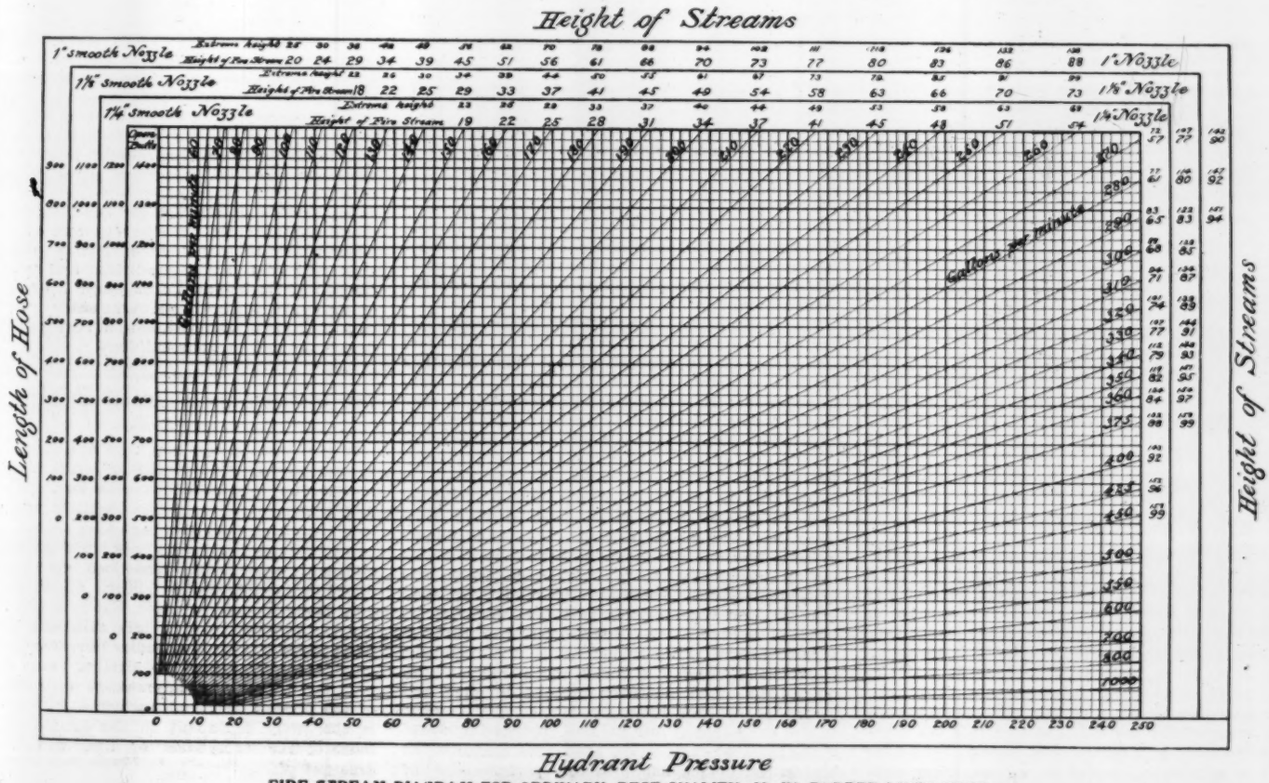
The principal considerations leading to this decision were that the proposed bridge, being so conspicuously located on a fine residence avenue, and in full view of a large area, within which was the National Zoological Park, should be of a monumental character, and the masonry type, above all others, fulfilled this condition as well as that of suitability.

The history of metallic viaducts is one of continual outlay for maintenance and repair, with a frequent ending by the replacement of the structure by one of masonry. The advantage of economy of first cost in a metallic structure is thus largely offset by the necessary annual outlay for its proper preservation, and where the cost of a masonry and a metallic viaduct can be brought within the same class of figures, as in this case, the decision in favor of the more substantial construction is easily justified.

A metallic structure progressively deteriorates with age; a masonry one, especially a concrete one, progressively improves.

The design of viaduct recommended is specified as a masonry one, and it follows that the cost of its construction can be made to range through wide limits, according to the class of masonry selected and used. The most expensive kind is, of course, first-class granite ashlar, but this is believed to be practically beyond consideration by reason of its excessive cost in comparison with other substantially equivalent material. It would, of course, be absolutely the best, but the additional quality secured would be purchased at too high a price, as a comparison of the estimates will show. We recommend that the concrete design of Mr. Morison be used in the construction of this bridge, if appropriation therefor be authorized.

The report also recommends that if the viaduct is constructed the services of Mr. Geo. F. Morison as consulting engineer shall be engaged. It is further recommended that the necessary appropriation of money to build the viaduct shall be made by Congress.



FIRE STREAM DIAGRAM FOR ORDINARY, BEST QUALITY, 2½-IN. RUBBER-LINED HOSE.
(Based on Freeman's "Hydraulics of Fire Streams.")

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post Office as Second-Class Matter.

Published every Thursday

at St. Paul Building, 220 Broadway, New York, by

THE ENGINEERING NEWS PUBLISHING COMPANY.

D. McN. STAUFFER, Vice-President, } - - EDITORS.
CHARLES WHITING BAKER, Secretary, }

GEO. H. FROST, President, } - - - BUSINESS MANAGERS.
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ALFRED E. KORNFELD, New York. } ADVERTISING
F. A. PECKHAM, Chicago, } REPRESENTATIVES.

PUBLICATION OFFICE, ST. PAUL BUILDING, NEW YORK.
WESTERN OFFICE, MONADNOCK BLOCK, CHICAGO.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.60 (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). SINGLE COPIES of any number in current year, 15 cents.

Mailing addresses may be changed at will by sending both old and new address. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 326 means that subscription is paid to the 32d week (that is the issue of Aug. 12) of the year 1897; the change of these figures is the only receipt sent, unless by special request.

ADVERTISING RATES: 20 cents per line. Want notices, special rates, see page 28. Rates for standing advertisements sent on request. Changes in standing advertisements must be received by Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

The city of Ithaca, N. Y., has taken steps to provide a reference library of treatises and periodicals relating to municipal affairs for the use of city officers and members of the City Council. At the meeting of the City Council, on Feb. 3, Alderman Thurston, better known to our readers as Dr. R. H. Thurston, Director of Sibley College, Cornell University, offered the following resolution, which was adopted:

> Resolved, That the mayor be and he hereby is authorized to direct the city clerk to subscribe for or to purchase books and periodicals having special reference to municipal affairs on request of members of the council or officers of the city, with the purpose of securing a library for consultation, but not for circulation, that shall be of service to the city officials in municipal matters, but the cost of such periodicals and other publications shall not exceed $10 annually for the periodicals and $25 for other purchases. The books in the library thus collected shall be in the immediate care of the city clerk and shall not be taken from his custody, either singly or collectively. Bindings shall be plain and durable. A catalogue shall be introduced into the inventory book of the city clerk.

The example of Ithaca is one which might be profitably followed by a great many cities throughout the country. A great deal of the poor work done under direction of municipal officers is chargeable not to dishonesty but to ignorance. The so-called "business men's" administrations, which have at times conducted the affairs of some of our cities, have not always been as successful as anticipated, merely through the fact that the business men, when placed at the helm, found themselves more ignorant on many matters than the professional politicians, whom they displaced. Good intentions are a better foundation than party politics on which to build a successful city government, provided the good intentions are backed up by ability and by an intelligent knowledge of the business which a city government has to carry on.

Such a knowledge is not a matter of intuition; it must be gained by study, like any other knowledge. The fact that such knowledge is essential to wise and intelligent action on the part of city authorities is already recognized to a greater or less extent, and when a city proposes to undertake any new public works of importance, it is frequently in order for a "junketing" trip, to be taken to some other city to learn its experience.

From such journeys a certain amount of knowledge is sometimes derived; but as a rule the average non-expert city official, who goes to see a filter plant or a pumping engine or an electrical subway, or any other piece of engineering work with which he is wholly unfamiliar, is quite unable to examine it intelligently. We are inclined to believe that if all the money that has been expended on such journeys by city councilmen had been devoted to the purchase of books and periodicals relating to municipal engineering, and if all the time spent on such trips had been given to their study, the actual knowledge gained might have been increased about tenfold.

We are informed that Engineering News was the first periodical selected by the Ithaca authorities for their reference library, a compliment which we highly appreciate.

The floating dry-dock scheme of the International Dry-Dock and Construction Co., now before Congress, will not bear close scrutiny, when the interest and convenience of the government are honestly considered. The general plan of the proposed dock is not made public, other than to state that it will be of the "Clark & Stanfield model," and some of the claimed advantages of such a dock are too absurd to need comment. But assuming that this floating dry-dock would do nearly all that its promoters claimed for it there are other and potent reasons why the government should carefully avoid going into partnership with this private corporation which proposes to do public work—for a consideration. Briefly stated, the modest proposition of the backers of this floating dry-dock scheme is that the Federal government should make a contract with them for twenty years, and pay annually the sum of $90,000 for the use of this dock for 100 days in the year. It is also announced that this dock is to cost $1,500,000; therefore, the granting of the subsidy and the credit of the United States would enable the International Dry-Dock Co. to borrow this capital at, say, 4%, and leave $30,000 per year of the subsidy fund to be expended for operating expenses, or the formation of a sinking fund. In commenting upon this one-sided financial proposition, the Brooklyn "Eagle" suggests that while the government would thus practically provide all the capital and pay at least the bulk of the annual interest and operating charges, it would have the use of the dock for less than one-third of the time in each year. But, as the avowed purpose of the company is to do a general docking business, and as a ship once in the dock and under repairs cannot be put into the water until these repairs are completed, the government ship would have to await its time, no matter how pressing the emergency. The government use of the dock would, therefore, be merely nominal, at least in times of peace, and as the "Eagle" remarks, it would get its 100 days when they were not advantageous, and lose all advantages of the dock at the time of greatest need. Then, too, as the repairs on a warship very generally demand the use of heavy machines and tools and extensive shops, and as these now under government control could not be transported to the floating dock, the International Company, doubtless expects to make another neat profit out of Uncle Sam by providing these tools and doing the work of repairs.

The whole scheme is an affront to the engineering and constructive ability of the naval engineers and proposes an expensive and unsatisfactory method of carrying on the government's dry-dock work. If any change of methods in dry-dock construction and operation is seriously proposed, the reform would be started at the wrong end by the acceptance of any such proposition as that now made. The government can secure as efficient and experienced designers and builders of dry-docks as any private company, and it can build as good docks as any individual—if it will first turn its attention to building up a better bureau to control their design and construction. The present Brooklyn dry-dock scandal, and the opportunity seized upon by interested private parties, are the direct outcome of a moss-grown policy which heads a government engineering bureau of docks and yards with an official who does not even pretend to have any knowledge of the duties or details of his office. In the execution of any private engineering work, if the nominal engineering head were neglectful of his duties, or inefficient in the performance of them, exactly similar results to those recorded in Brooklyn would follow bad design, careless or criminal inspection and lack of proper engineering supervision, and bad work and ultimate failure would as inevitably be the outcome.

But suppose the past and present policy of heading the Bureau of Docks and Yards with a line officer of the Navy were reversed, and that this bureau was placed under the charge of an engineer of recognized ability and long training in his special work. If this had been done some years ago, in accordance with the dictates of ordinary business policy and in the true interests of the government, it is safe to say that we would now have efficient, ample and well-located government dry-docks, and there would be no room for the strike for a government subsidy that is now being made. In the case of the Brooklyn dry-dock No. 3, for example, an able, expert and conscientious chief would, in the first place, have eliminated certain features of the original design that invited failure; and he would have had his professional reputation and the interests of the government sufficiently at heart to have closely and intelligently watched the plans and the progress of the work. A chief of this type would have frequently visited a work of such great importance; and the engineer in direct charge, knowing that his work was liable to criticism at any time by an expert, would have paid closer attention to his business and have exacted better work from all about him. It is a law of nature that water will not rise higher than its source; and if the responsible head of any enterprise fails in his duties, from lack of training and experience or from any other cause, the same failure may be expected all along the line of his subordinates.

We repeat then that the government should commence this much-needed reform in its dry-dock construction, not by a subsidizing private corporation to do its work, but by placing its engineering work under competent engineering control. If the present corps of naval engineers and naval constructors cannot provide the right kind of a chief—though we think they can—then let the government go among civilians and seek out the best man for the office that the engineering profession can provide. We will guarantee that the professional employees of the government would welcome the appointment of any man of established professional reputation to this office. Their own work would be better appreciated, and their individual services would become more valuable to the nation by reason of this appreciation. Here is a bureau that has in its charge engineering work that has cost the nation over $50,000,000. It is eminently a technical bureau, and all its officers are engineers—saving the chief alone. The country has paid dearly, in money wasted, in bad work and in the national disgrace of being forced to send our warships to foreign ports for docking for the continuance of out-of-date methods in selecting this chief; and the conditions now demand that the red-tape be cut and a new and wiser policy be inaugurated. Power to the hand that will cast aside tradition and place the Bureau of Docks and Yards where it ought to be, on a sound business basis. When this is done, and not until then, can the nation take pride in its dry-docks and in their builders.

THE DISTRIBUTION OF MANUFACTURING INDUSTRIES.

It is a well-known fact that the steam engine, the railway and the steamship made possible the building up of manufacturing centers, and entirely revolutionized the economic condition of all civilized countries. At the beginning of the present century, each community was, to a great degree, sufficient unto itself. The food used was produced in the immediate vicinity. Clothing was not only made in the household, but to a large extent the cloth from which it was fashioned was also made there. Each community purchased from the outside world only a few articles, many of them luxuries. The vast interchange of commodities of the present day, under which every community is absolutely dependent on the outside world for most of the necessities of life, was then not dreamed of.

The great inventions of the nineteenth century have overturned this primitive old social system. The invention of labor-saving machinery, coupled with the application of the division of labor, made it possible to manufacture goods in a mill at a small fraction of the cost of their production in the household or the small shop. The steam engine and the turbine water-wheel came in the nick of time to furnish the power for these mills, and the steam locomotive on the railway and the steamship on the water furnished a means of distributing the products over a wide area.

These modern economic changes have been so often pointed out and commented upon that we presume they are familiar to most of our readers; but it is by no means so generally appreciated that a reaction from this process has begun, and it has already assumed such proportions that it deserves the serious attention of engineers; for it has a very important bearing on such common questions as the location of industries, the cost of power, the growth and volume of transportation, and other matters of interest to the profession.

An excellent illustration of this change is the situation in the cotton manufacturing industry. Most of our readers are doubtless aware that all through the great cotton manufacturing districts of New England, profits have been growing steadily smaller for several years past, until now the mill-owners claim that wages must be reduced if the mills are to run at all. It is not so generally known on this side of the water, however, that in Lancashire, the center of English cotton manufacture, and the greatest cotton manufacturing district in the world, exactly similar conditions are prevailing. The mill-owners announced to the operatives a few months ago that a cut of 5 per cent. in wages was an absolute necessity. The operatives decided to meet the cut with a strike. An improvement in the market made it possible to postpone the reduction; but it is not believed that it can be permanently put off.

For more than sixty years a little district in New England and a still smaller one in old England have been producing nearly three-fifths of the cotton goods used by the world. Why have they been able to do so? Both sections were remote from the cotton growing regions. We can only ascribe the original founding of the industry to the enterprise of its original promoters, and its growth in after years to the fact that with the industry once established and its profit proven, it was easier to find capital and skilled labor for new cotton factories there than elsewhere.

For many years cotton manufacture in both these great industrial centers has been a very profitable business, but to-day the evidence seems positive that the profits are reduced to a point where only the best equipped and best managed mills, producing a high grade of goods, can pay a dividend.

Prices of the finished product have been reduced by the competition of mills in the South and in India, China and Japan. For a dozen years or more great cotton mills have been going up in Georgia and the Carolinas. Many of them have unfailing water-power; the mild climate lessens the expense for such fuel as is necessary; they have the latest improvements in buildings and machinery; labor is cheap, abundant and industrious; the cotton is grown in the vicinity. It may well be believed that the well-equipped and well-located cotton mill in the South can produce goods at smaller cost than its New England competitor.

The cotton mills which have been established in India, Japan and the open ports of China, have a market at their doors. They have the raw material close at hand, and have labor in unlimited quantity which costs a small fraction of that employed in the Lancashire mills. Under these circumstances neither England nor American cotton mills can hope for many years longer to dispose of their surplus products in the Orient, nor can the skilled spinners and weavers of New England look for high wages when they have to compete with the "poor whites" of the South, and with the cheap labor of Japan, China and India.

But the keen student of affairs cannot fail to see something more in the present situation of the cotton industry than mere matters of cheap labor and freedom from factory legislation. Anyone who watches the course of modern events and the trend of public opinion must discern the fact that no nation or community at the present time rests content to be a mere producer of raw materials and obliged to import from other countries its manufactured goods. Every nation that aspires to any prominence in the commercial world to-day is striving to build up its manufacturing industries, and not only to supply its own needs, so far as its circumstances will permit, but to capture such share of the trade of the countries of Asia, Africa and South America, as the enterprise of its people may make possible. The same spirit actuates different parts of the same nation. The South is already not only independent of New England in cotton productions, but is taking a large share of the home trade, which New England formerly enjoyed; and the movement is by no means at an end. The other cotton growing states, we may be sure, will not be permanently content to buy their cotton fabrics of Georgia and the Carolinas. The Pacific coast will not for many years be content to import its manufactures from the East. So much of them as its climate and its supply of raw materials and labor permits are sure to be made there. The Northwest is restive at having its wealth of iron ores smelted in Pennsylvania and Ohio furnaces, and iron and steel manufacture is likely to be a growing industry in the states of Michigan, Wisconsin and Minnesota.

These are but single instances of the multitude that will occur to every thoughtful observer, which go to prove our contention that there is a strongly marked tendency at the present day to a wider distribution of manufacturing industries over the civilized world. Of course, this is modified largely by local conditions and local supplies of raw material. It would be impossible, for example, to build up a great lumber manufacturing industry in a section stripped of its forests; and any region which has to bring both ore and fuel from great distances can never achieve greatness in iron manufactures. But facts like these in nowise contradict our proposition respecting the distribution of industries.

For the better part of this century England has been the world's workshop. Indications are not wanting that the day of her supremacy is past. The colonies she has planted would be false to the spirit of enterprise and independence that has brought England herself to her present proud position if they were content to sit down and live by agriculture and mining and depend on other countries for manufactured goods. The nations of Europe all strive so to shape their legislation as to keep the home market for themselves, and, at the same time, capture as much as possible of the export trade. It is true that the exhaustion of her mines of Bessemer ore, the increased depths of her coal mines, and the fact that lumber and many other raw materials must all be imported, have much to do in handicapping England in competing for the world's trade. It is true, also, that the restrictions imposed by labor unions and factory legislation probably operates to some extent at least as an additional handicap. But besides these causes there is also the ambition of other nations to develop their own resources and supply their own needs—to achieve commercial as well as political independence.

In the movement now under way for the development of American export trade, it is well to bear these facts in mind. We need not expect to permanently supply European nations with any goods which their own natural resources will permit them to make. Our automatic tools may for a time enable us to win a trade in certain lines; but European manufacturers will eventually buy the tools that will enable them to make the machines or products themselves. In the countries of South America, Asia and Africa, however, the building up of manufacturing industries will be a slower and longer task; and such of their trade as we may secure, we may reasonably expect to hold for many years.

In conclusion, we desire to emphasize the fact that it is modern inventions and the spread of modern civilization which originally brought about the concentration of manufacturing in a few countries and in small districts in those countries, but now is making possible the spread of manufacturing over the civilized world. The invention of automatic machinery has greatly reduced the amount of skilled labor necessary in manufacturing, and has made it possible to produce articles that once required a high order of skill, with ordinary laborers as operatives. The spread of civilized laws and customs and the tying together of the world with a network of railway and telegraph lines has made the field for the investment of capital world-wide. Under these circumstances a tendency will all the time exist toward bringing together the factory and the raw material and lessening by so much the cost of production.

LETTERS TO THE EDITOR.

Heating Value of Blast Furnace Gas.—Correction.

Sir: In the article entitled "Boiler Testing with Various Fuels," appearing in your issue of Feb. 3 (p. 78), there is evidently an error in the statement of the heating value of the fuel gas described. The heating value of this gas is 1,117 B. T. U. per lb., and not 11,187 B. T. U. Including the heat due to the temperature of the entering gas, it is 1,117 + 108 = 1,125 B. T. U.

New York, Feb. 5, 1898. C. E. B.

The Computation of Strains in Coal and Grain Bins.

Sir: There seems to have arisen a slight controversy between Prof. Howe and myself about the pressure in grain bins. I tried to call attention to a misstatement in the article written by him, but made the error of calling (E) (a C), which he corrected in your issue of Jan. 28. I also see that he has proven his formula to be only another form of the one I used.

I wish to acknowledge the correction Prof. Howe made in my solution; taking the projection of M A instead of the full length as I should have done had I followed the standard rule of pressures, viz.:

The total pressure on any surface "curved or plane" equals the area of that surface multiplied by the average pressure exerted upon it. Very truly,

George F. Barton.

231 Lormore St., Elmira, N. Y., Jan. 31, 1898.

The Questions Used in Examining Candidates for Assistant Engineerships in the Naval Civil Engineer Corps.

Sir: May I offer a criticism upon the examination of the candidates for naval engineer? The questions which are published in your last number are somewhat encyclopedic in scope, but with a few exceptions are very elementary and require only a familiarity with the easier parts of the text books of our technical schools. Such an examination is well suited to the young graduate who can most easily prepare himself for it. Familiarity with college text books does not necessarily make an engineer, however. A dozen questions involving some of the more or less puzzling difficulties met with only in practice, and calling for some original thought and invention would afford a better test for candidates for such an important position.

If the young men who received the appointments do not have the practical training which should be a part of the preparation for their work, they doubtless have the ability to acquire it in time, but it may be said that no individual company, or corporation will pay good salaries while training their engineers, since they can easily get plenty of well trained ones. Yours truly, E. D. Cummings.

Aspinwall, Pa., Jan. 31, 1898.

(Our examination of the questions referred to led to an opinion quite the opposite of that expressed by our correspondent. We have published in Engineering News a good many sets of examination questions for engineers, but we do not recall any which contained so many questions calculated to test the applicant's practical ability as an engineer rather than as a mere computer as the set which our correspondent criticises. Of course, any such examination must contain questions to test the applicant's knowledge of elementary facts; but the proportion of questions in this examination calling for the exercise of judgment was unusually large.—Ed.)

Graphite Paint as a Coating for Iron Structures.

Sir: An article by Mr. R. W. Wing in your issue of Dec. 23, entitled "Red Lead as a Protection for Iron Structures," leaves much to be desired, inasmuch as Mr. Wing confines himself entirely to general statements advocating red lead paints, without discussing basic principles at all. His strongest argument in favor of red lead for paint seems to be the fact that it has been used for centuries, or in the words of Mr. Wing himself, "On service and history it bases its claim to confidence." If the development and evolution of human affairs had been entirely controlled by that principle we would now have no steel

frame structures to be covered with either graphite or oxide paint.

As red lead was doubtless originally an improvement over something more primitive, so graphite paint may be, and in our opinion is, an advance on any paint that has an oxide or metallic pigment for a base.

Mr. Wing also infers that the graphite paints' whole claim to consideration lies in the fact that they have successfully withstood severe laboratory tests, which he considers unimportant. Granting that laboratory paint tests on plates are somewhat unsatisfactory, and not final, there can be no doubt but that they clearly determine the effect of chemical action on paint pigments and they have shown conclusively that graphitic carbon is an inert, refractory substance, absolutely unaffected by any solution known to chemistry.

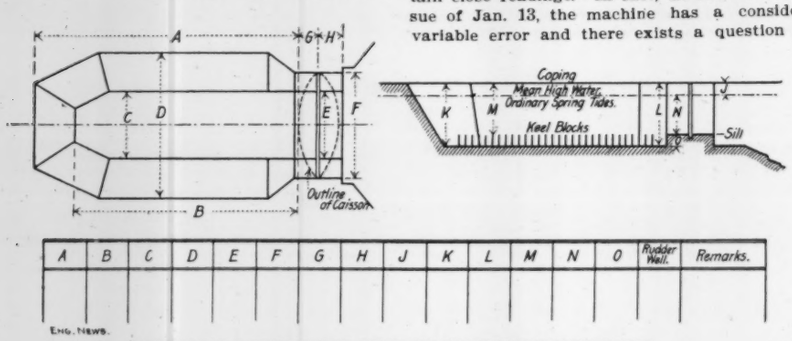
It would certainly seem that theoretically a paint whose pigment is unaffected by chemical action, which pigment has almost as little affinity for moisture as oil itself, and whose specific gravity is light enough to give a covering capacity much greater than lead or oxide, would promise the best results, and theory in this instance is borne out by experience and actual practical results.

Detroit Graphite Mfg. Co.,
By Howard M. Wing.

256 Broadway, New York, Feb. 3, 1898.

Dry-Dock Dimensions.

Sir: In Engineering News for Dec. 16, 1897 (p. 385), are given the general dimensions of a number of dry docks. A comparison of these dimensions with those given in "The Naval Pocket Book" (1897) shows a decided difference in each case. It is therefore pertinent to inquire what is meant by the length; the breadth; or the depth of sill at high water. Future uncertainty may be removed by defining the points to which the dimensions refer, and



A	B	C	D	E	F	G	H	J	K	L	M	N	O	Rudder Wall.	Remarks.

ENG. NEWS.

A STANDARD SYSTEM FOR RECORDING DRY-DOCK DIMENSIONS.

the state of high water, whether at ordinary, spring or neap tides or at the mean height of the same.

The dimensions of dry docks are very important to maritime interests; particularly the maximum useful dimensions. The writer uses the accompanying sketch system for dimensions of dry docks in which the dimensions "A" and "B" are measured to the bilge of the caisson for clearance.

It is also mentioned in the same article that the Southampton dry dock is the largest single graving dock in the world. The following is a list (taken from "Naval Pocket Book," 1897) of dry docks in Great Britain, which may be classed as larger or largest, depending upon the point of view of length, breadth, or depth of sill:

Owner or location.	Name.	Length, ft.	Br'dth, ft.	Depth on sill at O. H.W., ft.
London & India Docks, Joint Committee	No. 1	875	70	35
	No. 2	875	70	30
Liverpool	Herculaneum Docks, No. 1	758½	60	22¾
	" " 2	753	60	22¾
	" " 3	768	60	22¾
	New dock	900	?	?
Birkenhead: Mersey D'ks & Harbor B'rd.	No. 1	930	60	23¾
	" 2	750	48½	26¾
	" 3	750	85	26¾
Glasgow: Clyde Navgtn Trust.	Govan No. 3	900	85	26
	Cessnock	880	83	26½
Belfast: Harbor Co'mis'n'rs.	Alexandra	825	80	25¾

Note.—The above docks are constructed of masonry.

Yours faithfully, Robert A. Cummings.

714 Girard Building, Philadelphia, Pa., Jan. 29, 1898.

(The suggestion made by our correspondent is a good one, and the data indicated are necessary for an intelligent understanding of the true dimensions of a dry dock. The list referred to was an unofficial one, and the fact that it differed from others only emphasizes the necessity for some more systematic classification.—Ed.)

Test of Cast Iron Columns by the New York Building Department.

Sir: Referring to the table of results of breaking tests of cast-iron columns as published in your issue of Jan. 13, page 28, I would call your attention to the following comparative table, which is the result of a careful review of the original report and of the table published by you.

You will notice in this new table that the total ultimate (maximum) resistance and ultimate (maximum) resistance per sq. in. have been considered, and I think should be published in addition to the table you have already given out. In column I., you will note, there is no change from your published report.

Very truly,
William W. Ewing,
Special Engineer Department of Buildings.

New York city, Jan. 31, 1898.

Col.	Areas per Eng. News.	Corrected areas.	Breaking load.	Maximum resistance.	Breaking load per sq. in. as per Eng. News.	Maximum resistance per sq. in.
I.	43.98	43.98	1,356,000	1,356,000	30,830	30,830
II.	48.03	49.03	1,330,000	1,330,000	27,700	27,126
B 2.	48.03	49.03	1,198,000	1,198,000	24,900	24,434
B 4.	49.48	49.48	1,246,000	1,246,000	25,200	25,182
(5).	50.84	50.91	1,632,000	1,798,300	32,100	35,323
(6).	51.52	51.52	2,082,000	*2,082,000	40,400	40,411
XVI.	21.99	21.99	651,000	651,000	31,900	29,604
XVII.	22.87	22.87	612,800	645,600	26,800	28,229
(7).	17.64	17.64	400,100	455,200	22,700	25,805
(8).	17.37	17.37	455,200	474,100	26,300	27,290

*Did not break.

(In the above table, under the column headed "Breaking load per sq. in.," it will be noticed that no attempt was made to give the figures below the hundreds place, owing to slight inaccuracies in measuring the area of the column section, due to irregularity in casting, and the fact that in the Phoenix machine it is out of the question to obtain close readings. In fact, as shown in our issue of Jan. 13, the machine has a considerable variable error and there exists a question as to the exact figure to be used in the thousands place of both "Breaking Load" or "Maximum Resistance." In deriving a formulae for general use the column headed "Maximum resistance per sq. in.," suggested by Mr. Ewing, would unquestionably be used. However, the slight changes introduced do not alter the conclusions drawn in our issue of Jan. 13.—Ed.)

Early Use of Tie-Plates.

Sir: In reading Mr. Tratman's book on "Railway Track and Track Work," which I got from you a short time ago, I find that on p. 42 he says: "While the tie-plate is a decidedly modern invention, it has already fully borne out the ideas of its designers," etc., etc., and again on p. 54, writing on the T-rail, he says that it was invented in this country by Col. Robert L. Stevens in 1830, and further on states: "In Europe this rail was re-invented in England in 1836 by Mr. Charles Vignoles." I do not dispute this statement, but it is certainly news to me.

Now, with regard to the tie-plates (or, as they are called in England, bed-plates), I can most emphatically deny that they are "a decidedly modern invention," as in Europe they have always been used with the "Vignoles" rail, as designed by Mr. Vignoles, whom I had the pleasure of knowing in years gone by.

It was used to my certain knowledge in 1858 on the Bilbao & Miranda Railway in Spain, which was built by the late eminent contractor, Mr. Thomas Brassey; Mr. Charles Vignoles was the Chief Engineer of the company and my late father-in-law was one of Mr. Brassey's engineers. From my personal knowledge it was used on the Lemberg-Czernowitz Railway in 1865, on which railway I was an assistant engineer, then on the Czernowitz-Suczawa Ry. in 1867, on which I was Resident Engineer, both of these railways being in the eastern part of Austria. It was also used on the Suczawa-Jassy Ry., in Roumania, in 1869, the two latter railways being continuations of the former, and Mr. Brassey being the contractor for all of them.

The rails we first used, that is on the Lemberg-Czernowitz Ry., were 18 ft. long, weighing 76 lbs. to the yard, with supported joints and tie-plates. Then on the Czernowitz-Suczawa Ry. we used rails 21 ft. long with suspended joints, the ties near the joints being moved with their centers 9 ins. on each side of the joint, also with tie-plates. In both cases a tie-plate, naturally smaller, was placed at the centers of the rails, the remaining ties remaining being spaced about 3 ft. apart, from center to center.

I had a drawing, or rather a lithograph (among others of bridges, etc., of the Lemberg-Czernowitz Ry., which I have kept all these years as a memento), of the section of the rail, and plan of the track, showing the tie-plates and how the ties were spaced, but on looking over the plans I find that the one of track joint and ties is so badly scorched by fire (I was burnt out in Chicago in the winter of 1893) that it is impossible to trace it or send it. I therefore enclose a plan of the level crossings, for different widths of roads, as of course they cross the main line. You will see the tie-plates, at the supported joint and middle of rail, also the spacing of the ties, the rails, as I mentioned, being 18 ft. long.

On the cross-sections you will see the section of the rail and the tie-plates. These latter are, of course, wider than the ordinary ones, so as to take in the guard rails, but they were the same pattern. We used, as you will see, fish-plates. You will also see the different pattern of the spike heads to that used in this country, and I must say that I prefer that pattern of head, as they are more easily drawn. They were driven at an angle, which I consider gives them a better hold. The ties were adzed at the rail seats so that the rails had a slight inclination inwards.

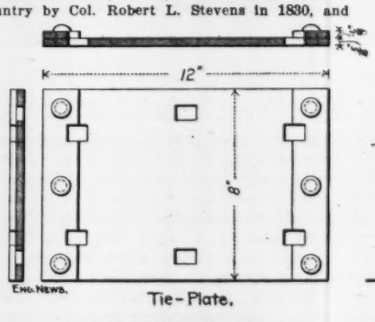
I write this in no fault-finding spirit, but merely to inform you that the tie-plate is not a "modern invention," that is, what may be called modern in things pertaining to railways.

I have read this book with much pleasure and interest, and fully appreciate the immense amount of labor and research the writing of it entailed. I was on the Canadian Pacific Ry., and any reference to the work on it is always pleasing to me.

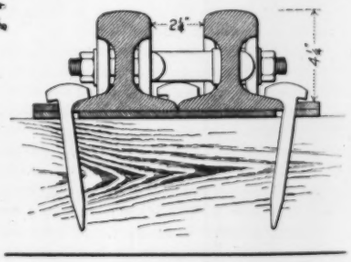
At the request of the sons, associates, and friends of the late Mr. Thomas Brassey, Mr. Arthur Helps undertook to write a work entitled "Life and Labors of Mr. Brassey," which was published in 1872, and a copy of it was presented by his eldest son, Thomas Brassey (now Lord Brassey), to all those who had held positions, either on the engineering staffs or otherwise, on his numerous contracts, covering the period from the date of his first contract in 1834 to 1870. I, among others, received a copy, and value it highly. There is a copy of it, I think, in the Chicago Public Library. The whole work would, I am sure, interest any civil engineer. The list of the contracts undertaken and completed by him between the years I have above mentioned is wonderful in showing how much can be accomplished in a lifetime.

Yours very truly, Henry MacCulloch,
Chief Engineer, Mineral Belt Ry.

Denver, Colo., Jan. 6, 1898.



Tie-Plate.



Transverse Section.

Tie-Plate at Grade Crossing. Rail and Tie-Plate at Level Crossing.

RAIL AND TIE-PLATE USED ON THE LEMBERG-CZERNOWITZ RY., (AUSTRIA,) IN 1865.

(As to the invention of the T-rail or "flange" rail, that is a matter of historical record. Col. Stevens' drawing and specifications of 1830-31 are

still in existence, and were reproduced a few years ago in our columns. His rails, however, though rolled in England, were made for and shipped to American railways, and as he had no special interest in European railways he probably did not exhibit his rail to any extent in Europe. It was, therefore, but little known there when introduced by Mr. Vignoles, and became then (as now) very generally known as the Vignoles rail. This term is, however, more commonly used on the continent than in England, where the term "flange" rail is more generally used.

As to the tie-plates, the sentence referred to by Mr. MacCulloch should have been to the effect that the "light and inexpensive tie-plate which embodies its own fastenings to the tie is a decidedly modern invention." The present wording arose from the fact that historical references to European practices were mainly omitted or cut out in order to keep the size of the book within reasonable limits, the information on American practice being the most important consideration. Foreign tie-plates are briefly referred to on pp. 48-49 of the book. The tie-plate or bed-plate dates back beyond 1858, and was used on some European lines as early as 1838 and 1840, but none of these early tie-plates were of the "self-fastening" type developed in this country.

The lithograph sent by Mr. MacCulloch, from which we have traced the accompanying illustration, shows grade crossings with iron guard rails bolted to the track rails, the flangeway being maintained by spacing sleeves on the bolts. These plates had a rib about ¼-in. thick and 1½ ins. wide on each side, secured to the plate by three countersunk rivets. Each tie-plate had six spike holes, the two middle ones being for spikes driven into notches in the inside flanges of the rail. There were three plates on each length of guard rail, placed at the joints of the guard rail and the track rail. Where guard timbers were used instead of guard rails, an iron plate was let into the inner top edge and secured by screws.

The peculiar shape of the rail, with its very heavy web, is notable. The heavy head of the spike is better than the nail head of the ordinary American spike. We believe experiments have been made in this country with spikes driven in a slanting direction under the rail, but are not informed as to the results. The broad, flat, Davies spike, introduced a few years ago, was driven in a slanting direction across the tie, but this is not now being used.—Ed.)

Notes and Queries.

P. asks: "In Portland concrete work faced with 1 to 3 or 1 to 2 mortar or with pure cement I find numerous hair checks; also numerous large checks which, during wet weather, make the face look as if it were of stone and were cracking all to pieces. Yet in general the checks seem to be lines of a hard and almost black material. Are these checks an element of danger? Are they liable to develop into cracks? What is the cause and what is the remedy?

"Where cement or mortar facing is streaked with white or is uneven in color, how can a uniform color be best obtained?

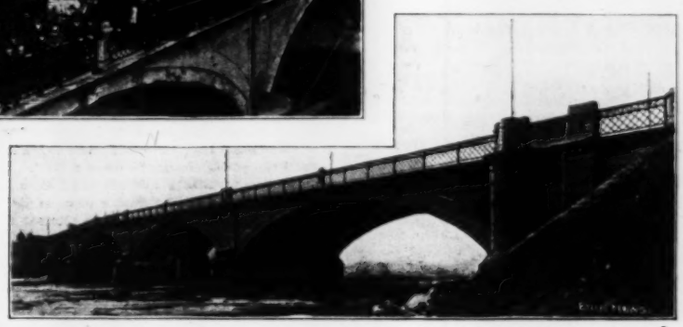
"What is the best and most durable finish for bridge piers, pure cement, 1 to 2 or 1 to 3?"

THE COMPLETION AND TESTING OF THE MELAN CONCRETE ARCH BRIDGE AT TOPEKA, KAN.

We publish herewith two views, which show the general appearance of the completed Melan concrete arch bridge at Topeka, Kan., and the same structure undergoing an "actual" test which was instituted for the delectation of the public and the newspapers. In our issue of April 2, 1896, the design and construction of this bridge was illustrated in detail, and a very full abstract of the specifications given, and in our issue of Sept. 23, 1897, a view and brief description of the progress of work were published. The accompanying views bring the history of the construction to a conclusion.

As will be remembered, this bridge consists of five arch spans, one 125 ft., two 110 ft., and two 97½ ft. long. All the spans are constructed of concrete and steel, according to the Melan system. The work of construction was begun in October, 1896, and the bridge was completed and thrown open for traffic during the present month. The test which is illustrated consists of piling railway iron and brick on the sidewalks, and placing upon the roadways loads of coal and other material weighing from 6,000 lbs. to 14,000 lbs., with people wherever they could stand. This loading caused no discernible movement of the bridge, either vertically or laterally.

Keepers & Thacher, of Detroit, Mich., were the designers and builders of the bridge, and Mr. H. V. Hinckley, M. Am. Soc. C. E., of Topeka, Kan., was the engineer in charge. We are indebted to Mr. Hinckley for the photographs from which our illustration was prepared.



VIEW OF COMPLETED MELAN CONCRETE ARCH STREET BRIDGE AT TOPEKA, KAN.
Keepers & Thacher, Detroit, Mich., Designers; H. V. Hinckley, Topeka, Kan., Engineer-in-Charge.

BAD SEWERAGE CONSTRUCTION AND PROPOSED IMPROVEMENTS AT WEST HARTLEPOOL, ENGLAND.

Remarkably poor sewer construction at West Hartlepool, England, is shown, and needed remedies ably presented, by Mr. J. W. Brown, Assoc. M. Inst. C. E., Borough Engineer, in a report on a proposed new sewerage system. When Mr. Brown took office in 1884 there were practically no sewer records in existence. In 1885 he recommended that such records be compiled, but it was not until 1890 that he received authority to begin the necessary surveys and examinations. He found it necessary to dig down to the sewers, in some instances, to learn their character. The appropriations were made in small sums, so the record work went on slowly. In 1895 he was instructed to report on a new system, which he did some months ago. From the report, a copy of which Mr. Brown has kindly sent us, it appears that the borough has an estimated population of 52,000; an area of 2,470 acres; a death rate in 1895 of 16.2 per 1,000; an assessed valuation, or "ratable value," of about $675,000; a bonded indebtedness of about $350,000; and an average annual rainfall of 22.6 ins. for the past ten years. The borough is located on the sea coast, and the sewage is discharged into tide water without treatment.

Mr. Brown now has records of about 25¼ miles of sewers. Most of these have been constructed without any attention to alinement and with little regard to grade, being laid with a hand level, and that without much care, in some cases. Brick, tile and pipe sewers have had holes smashed in them when new branches were to be laid and the new sewers laid up to these irregularly-shaped holes in a hit-or-miss style. Sometimes brick or stone were placed around the connections and sometimes not even this attempt to secure a joint was made. Straight lengths of pipe have been used to form curves, instead of using bends, leaving great gaps at the joints for the sewage to pour out into the ground.

Mr. Brown has laid out a new system of sewers, estimated to cost about $350,000. He has had current observations made to aid him in designing the tidal outfalls, has gaged the flow of existing sewers and studied the rainfall records. An allowance of 2 cu. ft. per min. per acre has been made for surface drainage and 42 U. S. gallons of sewage per capita. The advisability of constructing a storage reservoir for a part of the surface drainage, apparently from the country district, is suggested for consideration. The water so stored could be discharged in moderate quantities after storms, perhaps rendering unnecessary the enlargement of one of the main sewers. The water might also be piped through the streets for use in sewer flushing and street sprinkling.

This report shows that notwithstanding the claims often made by American municipal reformers regarding the superiority of the government of English municipalities some instances of misgovernment can be cited which are as bad as anything in the same line on this side of the water. We do not wish to be understood as underrating the character of the management of municipal affairs in many English cities and towns. A tendency of municipal government in all countries is for each city to insist on obtaining its experience for itself instead of profiting by that of other cities. This might be extended still further to apply to individuals. Probably experience will continue to be the best teacher, as well as a dear one, for some centuries to come.

THE EFFICIENCY OF BOLTED JOINTS.

Prof. Gaetano Lanza, of the Massachusetts Institute of Technology, writes us concerning the article in our last issue, p. 79, on "Tests of the Efficiency of Bolted Joints," that the following lines from the "Technology Quarterly" should have been quoted to explain what was the special problem on which it is sought to obtain light by these tests:

The fourteen tests on bolted joints given in the following summary were planned with the aim of finding the effect of the efficiency of the joint, and on the tensile strength of the net section of increasing the compression per square inch in front of the rivets.

Prof. Lanza writes also as follows:

That this is an important matter is evident from the fact that in double shear joints it is generally the compression on the bearing surface rather than the shearing that has to be taken into account in designing the joint.

The values at present used, in the best practice, for ultimate compression on the bearing surface are from 90,000 to 100,000 lbs. per sq. in.

Now these tests show, with 7-16-in.-plate and double shear, bolted joints with one row of bolts, the compressions are as high as 173,000 lbs. per sq. in., and those are the tests showing the highest efficiencies of the series.

In other words, increasing the compression on the bearing surface up to this point, so far from reducing, has increased the efficiency.

We plan to carry this series farther, and to seek, if possible, a compression on the bearing surface that will be so great as to lower the efficiency, and, if we find it, we shall have a limit for compressions on the bearing surface for bolted joints of this kind.

Before, however, concluding that it is correct to apply the results to riveted joints, it would be necessary to repeat a portion of the series, using rivets instead of bolts, and it is our plan to do this, unless information derived from the tests themselves causes us to change our plans.

Now as to your conclusions: Of course, 32,000 to 38,000 lbs. per sq. in. looks low for shearing strength per square inch of steel of 96,000 lbs. tensile strength.

One reason is, doubtless, that in the bolted joint the gripping force is not as great as is the case in riveted joints, and hence the shear is not a pure shear, but there is bending, which doubtless lowers the strength of the bolts. Some steels have a shearing strength as high as 55,000 lbs. per sq. in.

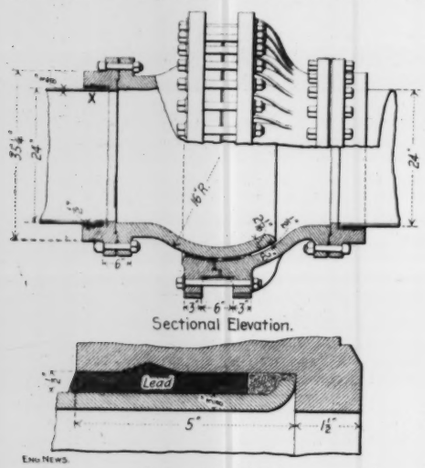
As to the lack of evenness of the distribution of the tension, you are doubtless right.

A SUBMERGED STEEL PIPE WITH FLEXIBLE JOINTS AT PORTLAND, ORE.

A steel pipe line is to be laid beneath the Willamette River at Portland, Ore. Bids for the work are to be received until March 15, but it is not expected that the pipe can be laid until next fall, on account of high water in the river, caused by winter and spring floods, followed by a rise in June, July and August, due to back water from the Columbia River, this last being due to melting snow in the mountains.

The pipe will be made from ⅜-in. soft steel plates and will be lap-welded. It will have an outside diameter of 24 ins. and the crossing will be about 2,100 ft. in length. The pipe is to be laid in from 7 to 28 ft. of water (maximum soundings in the summer of 1896), in a trench dredged to a depth of 8 ft. below the river bottom. The material to be dredged is believed to be mostly ½ to 2 ins. gravel, the total quantity being estimated as 20,000 cu. yds.

The pipe is to be made in lengths of not less than 18 nor more than 20 ft., with flexible cast-iron joints for each two lengths, these joints to have an angular movement of 15°. The joints will be composed of three parts, as shown in the illustration: A ball, socket and main flange. The



Flanged and Flexible Cast-Iron Joints on Submerged Steel Pipe at Portland, Ore.

D. D. Clarke, M. Am. Soc. C. E., Assistant Engineer City Water-Works.

ball must be turned to a perfectly spherical shape. Some further points of interest in that part of the specifications relating to the flexible and flanged joints, together with the sections relating to testing and coating the pipe, are as follows:

Flexible and Flanged Joints.

The balls and sockets will be put together in the shop and subjected to tests by first filling with water and afterward by hydrostatic pressure up to 250 lbs. per sq. in. In putting the flexible joints together the socket will be first put on its end, small flange down, and then the ball will be inserted and fairly rest on the projection of the socket, previously bored to the proper size and angle, then a fibrous gasket will be inserted and driven to the bottom of the cavity, when the melted lead will be poured from as many places as may be necessary to insure a solid body without seams or blow holes. After the setting of the lead the ball will be raised to ascertain the perfection of the work, and if found deficient it is to be made over. If found perfect, the ball will be replaced and the calking done in the usual manner. Then another gasket inserted as shown, the main flange put in its place and bolted, but not quite home, when again the melted lead is poured into the cavity.

To insure the perfection of the work this main flange will also be raised and the thoroughness of the work again inspected; then the flange will be firmly bolted home and the final calking done. If it is deemed necessary to warm up the parts in order to secure perfect work, it shall be done at the request of the inspector.

If during the process of testing any defects shall be manifest, all such shall be made good, and if required, new parts will be substituted in the place of the defective ones, all at the contractor's expense.

While under test, the ball will be removed from side to side, and thus ascertain if it fits perfectly in all positions when in place. To prevent end strains on ball and socket joint while under hydrostatic pressure, the caps shall be held in place by rods reaching from one to the other. The joint shall remain perfectly tight while the pressure of 250 lbs. per sq. in. is being applied and shall so continue until the pressure is entirely removed.

The flanges for the pipes will be secured in place by lead joints, the ends of the pipe being enlarged to form a bead to hold the joint in place, as shown on plan.

The number of bolts shall be 24 in the smaller flanges and 32 in the larger or main ones.

Testing and Coating Pipe.

Each section of the pipe must, after completion and before coating, be subjected to a hydrostatic pressure of 250 lbs. per sq. in., and must, during such test, be absolutely free from leaks or fractures.

The pipe sections when completed with flanges at each end, are to be thoroughly cleaned inside and out without the use of acid or other liquid, and subjected to a bath prepared and applied in the following manner:

Iron tanks of suitable size, placed over brick furnaces, to be filled nearly full with pure grade refined asphalt, equal to the "C" grade asphalt of the Los Angeles Oil Burning & Supply Co.'s product, of Los Angeles, broken into small fragments, the interstices filled with the best quality of natural liquid asphalt (maltha) known as "L" grade asphalt, not above 14°, gravity, Beaume test. The mixture shall then be boiled while being frequently stirred, until the entire charge becomes a fluid.

The temper of the mixture shall then be tested by immersing in the boiling fluid a piece of ⅜-in. plate, not less than 6 ins. sq., which must be allowed to remain therein at least ten minutes; it will then be removed and cooled in ice-cold water.

If the coating should then fly off upon striking the plate with a hammer, it will determine that the coating is too brittle; on the other hand, if the coating does not fly off under the hammer test, but softens at a temperature of 100° F., it will determine that the coating is too soft; then either more asphalt or more of the best quality of liquid asphalt must be added, until such temperature of the mixture is secured that will withstand the hammer test, and will also remain sufficiently hard and firm at a temperature of 100° F.

The pipe shall then be thoroughly submerged in the bath, and left therein at least 20 minutes, or long enough for the iron to attain the temperature (not less than 280° F.) of the mixture. It shall then be withdrawn, the coating allowed to stiffen for about eight minutes, and be again immersed a short time to thicken the coat.

Suitable appliances shall be furnished by the contractor, at his own expense, to lower, raise and revolve the pipes in the bath. The coating shall be of such thickness as the engineer of the water committee may deem necessary to effectually protect the metal.

Fresh materials must be added to the bath from time to time, in the right proportions to keep the mixture of the proper consistency, and the tank must be occasionally emptied of its contents, and refilled with fresh material. The materials for the mixture, the appliances and methods of boiling, melting or applying and testing the coating, shall be subject to the approval of the engineer in all cases.

In case that from any cause the coating on any length may be found to be defective, it must be renewed, and should the defect be from brittleness, or scaling, or improper composition, or application of the coating, it must be scraped off entirely, outside and inside, and another coating applied. All exposed portions of the flexible joints will receive a coating of P. & B. paint, equal to the coating of the pipes.

The steel pipe and the metal for the cast-iron joints may be bought in the East, but all the further labor involved must be done in Portland, Ore. Mr. D. D. Clarke, M. Am. Soc. C. E., is Assistant Engineer of the Portland Water-Works.

TABLE OF COEFFICIENTS FOR DESIGNING BRIDGE PORTALS.

The accompanying table of coefficients to be used in designing bridge portals has been sent us by Mr. C. S. Davis, Engineer, Massillon Bridge Co., of Massillon, O., and may be found useful by some of our readers. A very brief explanation will serve to make the use of the table clear. Proportion the

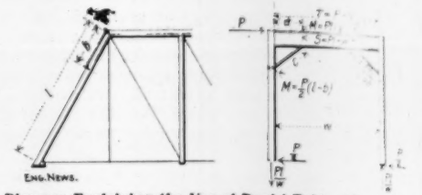


Diagram Explaining the Use of Davis' Table of Coefficients for Calculating Bridge Portals.

main portal for a direct thrust of $T = Pl \div 2$ and a bending moment of

$$M = Pl\left(\frac{1}{2} - \frac{a}{w}\right)$$

by the following formula; the value of M to be in inch pounds:

$$A = \left(T + \frac{M\,y}{r^2}\right) \div f$$

where A = area of both flanges; y = distance from center of inertia to outer edge of section; r = greatest radius of gyration of section; f = unit strain as determined by the compression formula. Proportion the web of the main portal for a vertical sheer of $S = Pl \div w$. Proportion the brackets for a reversible strain of

$$R = \frac{P\,l\,c}{2\,a\,b}$$

The unit strains given in the table are derived from a form of Gordon's formula, but any other compression formula may be used in the general formula in the place of this. The statement in regard to shear is not exact and will, of course, be true only with vertical end posts; it would be better to say shear in plane of portal at right angles to the flange angles instead of vertical shear.

Table of Coefficients for Calculating Bridge Portals.

$$f = \frac{15{,}000}{1 + .004\,L^2 \div r^2}$$

Flange angles, ins.	r^2 for ½-in. bet. angles.	Area four angles.	12 ft. R'y.	14 ft. R'y.	16 ft. R'y.	18 ft. R'y.	$y \div r^2$ for back to back of angles of 18-in.	24-in.	36-in.	48-in.	60-in.
4 — 2½ × 2 × ¼	1.70	4.24	11,195	10,245	9,375	8,520	0.1248	0.0910	0.0589	0.0435	0.0345
4 — 3 × 2 × ¼	2.45	4.76	12,215	11,470	10,715	9,948	.1237	.0904	.0586	.0434	.0344
4 — 3 × 2½ × ¼	2.09	5.24	11,755	10,900	10,080	9,260	.1283	.0929	.0598	.0440	.0348
4 — 3½ × 2½ × ¼	3.10	5.76	12,625	11,980	11,260	10,580	.1269	.0921	.0594	.0438	.0347
4 — 3½ × 2½ × 5-16	3.15	7.12	12,670	12,020	11,330	10,620	.1276	.0925	.0596	.0439	.0348
4 — 4 × 3 × 5-16	3.90	8.36	13,065	12,500	11,890	11,250	.1310	.0944	.0604	.0444	.0351
4 — 4 × 3 × ⅜	3.93	9.92	13,065	12,500	11,890	11,250	.1317	.0948	.0605	.0445	.0351
4 — 5 × 3 × 5-16	6.33	9.60	13,730	13,340	12,930	12,460	.1287	.0931	.0599	.0441	.0349
4 — 5 × 3 × ⅜	6.40	11.44	13,730	13,340	12,930	12,460	.1293	.0935	.0600	.0442	.0349
4 — 5 × 3 × 7-16	6.46	13.24	13,730	13,340	12,930	12,460	.1300	.0938	.0602	.0443	.0350
4 — 5 × 3 × ½	6.53	15.00	13,730	13,340	12,930	12,460	.1310	.0943	.0604	.0444	.0350
4 — 5 × 3½ × ⅜	6.01	12.20	13,680	13,250	12,800	12,330	.1337	.0959	.0611	.0447	.0353
4 — 5 × 3½ × 7-16	6.07	14.12	13,680	13,250	12,800	12,330	.1345	.0963	.0612	.0448	.0353
4 — 5 × 3½ × ½	6.13	16.00	13,680	13,250	12,800	12,330	.1351	.0966	.0614	.0449	.0354
4 — 6 × 3½ × ⅜	9.00	13.68	14,100	13,780	13,520	13,110	.1316	.0948	.0606	.0445	.0351
4 — 6 × 3½ × 7-16	9.08	15.88	14,100	13,780	13,520	13,110	.1323	.0951	.0607	.0446	.0352
4 — 6 × 3½ × ½	9.15	18.00	14,100	13,780	13,520	13,110	.1330	.0955	.0609	.0446	.0352
4 — 6 × 4 × ⅜	8.53	14.44	14,050	13,730	13,390	13,020	.1357	.0970	.0616	.0450	.0355
4 — 6 × 4 × 7-16	8.60	16.72	14,050	13,730	13,390	13,020	.1364	.0974	.0617	.0451	.0355
4 — 6 × 4 × ½	8.67	19.00	14,050	13,730	13,390	13,020	.1372	.0978	.0619	.0452	.0356

A NEW PORTABLE ROCK-CRUSHING PLANT.

In modern highway construction the ease with which rock-crushers can be transported from one locality to another is a consideration of great importance in any locality where the country rock is suitable for road construction. This fact is recognized by a number of makers of these machines and portable crushers of various types are upon the market. Generally, however, the crusher and the elevator and screen are separate machines and are mounted and transported separately, and it requires some time to set up the plant and get it in working order after moving. We show herewith an outline elevation of a complete crushing plant carried on four wheels, and which can be moved without taking down a single post, or removing a belt, and can be made to run in a few minutes at the end of a journey.

As shown in the illustration, the whole machine is supported on two steel beams, firmly braced together, which form a base for the whole plant. This base-frame is suspended from the rear axle by a yoke with a screw adjustment, by which it can be quickly lowered onto wooden sills, thus removing the weight of the machine from the carrying wheels.

This method has been found to be eminently satisfactory—in time saved and in efficiency of operation, as compared with the older practice of hauling separate parts, and putting them together again; or in taking the crusher off the trucks entirely and placing it on a prepared foundation. To run such a machine when resting upon its wheels, even when these are well blocked, is not satisfactory.

The operation of this machine is as follows: The entire plant is moved upon the four wheels to the point of next operation, without interference with

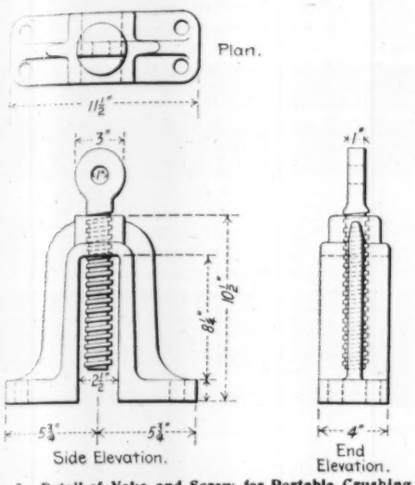


Fig. 2.—Detail of Yoke and Screw for Portable Crushing Plant.

any of its parts. When this point is reached, two wooden sills, carried with the outfit, are first placed under the ends of the I-beam base sills. The rear end of these I-beams is suspended from the rear-axle by the two screws, here shown in detail; and these beams can be lowered onto the wooden sill by simply turning the screws by the iron lever attached. When the rear end of the crusher has a bearing upon its sill the front end is then lowered by removing the front truck; the whole operation consuming only a couple of minutes. When the crushing at a given place is finished and the machine is again to be moved, this operation is reversed in an equally short time, and the plant is again upon the road.

Another advantage of the screw support which will appeal to contractors is that it furnishes a ready means of getting the machine out of a rut, should it become stalled by the wheels sinking into a soft place. By using the screws as jacks and alternately blocking under the steel sills and under the wheels, the latter can be raised out of a rut in a few minutes.

The apparatus is patented and manufactured by the American Road Machine Co., of Kennett Square Pa., to whom we are indebted for the drawings from which our illustrations are prepared.

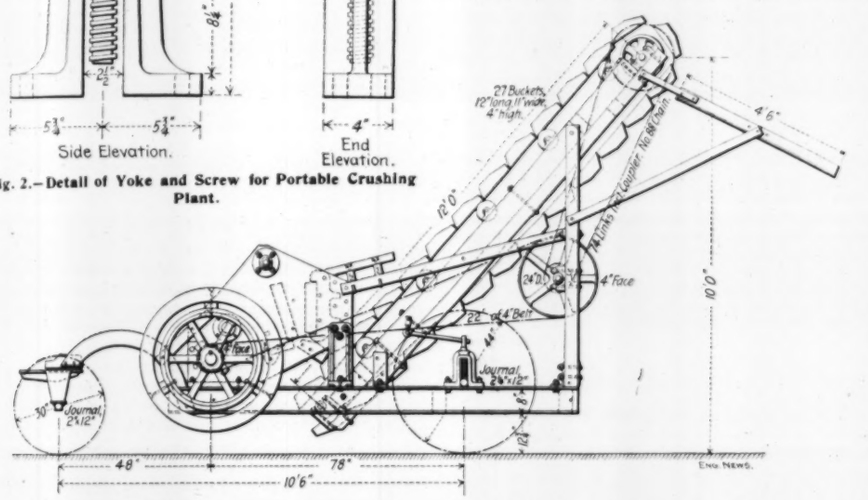


FIG. 1.—OUTLINE ELEVATION OF PORTABLE ROCK CRUSHING PLANT, SHOWING STEEL BEAM BASE AND SCREW SUPPORT.

The American Road Machine Co., Kennett Square, Pa., Builders.

THE COOLGARDIE, AUSTRALIA, WATER SUPPLY.

The scarcity of water in the Coolgardie gold fields of Western Australia has long retarded the development of mining operations and has added largely to the cost of living. In both the Coolgardie and the Kalgoorlie districts potable water is at present furnished by evaporation condensers, using the brackish water obtained from the locality, and costs from 4 to 12 cts. per gallon at the condenser. The average rainfall of the district is only 5 ins. per annum. The Premier of the Western Australian Assembly testified that it cost $5 to water his five horses, and the owners of the three mines then at work had to convey salt water for several miles for use in crushing the rock. As there is a permanent deficiency in rainfall, no stock can be raised, and the stock sent by rail for a meat supply has to be killed at once.

In this emergency the government of Western Australia has determined to supply this section with 5,000,000 gallons of water per day, at a cost of about $12,500,000, on plans prepared by Mr. O'Connor, M. Inst. C. E. As described in the London "Engineer," from which the profile here given is taken, the plan involves the construction of a pipe line 328 miles long, from a source of supply in the Darling, or Green Mount ranges of hills, near the coast. At the coast there is a satisfactory rainfall, at least 20 ins., and favorable sites for ample reservoirs exist. The source of supply would be the Helena River, at a point 320 ft. above sea-level. Here, a concrete dam 100 ft. high and 650 ft. long on the top, would be erected, on a rock foundation. The quantity of water impounded will be about 4,619 million gallons; and the net amount available, after allowing a depth of 20 ft. at the dam for the accumulation of silt, etc., and 7 ft. from the top-level for evaporation and soakage, will be 3,300 million gallons. The water-shed has a drainage area of 547 sq. miles; it is mostly hilly and rocky, and is sparsely settled so that there will be no fear of pollution.

The quality of the water is excellent; and though no records of rainfall and evaporation exist at this point, the annual rainfall is assumed at 20 ins., and it is figured that if only 3% of this finds its way to the reservoir it will fill it. The rainfall should equal that at Perth, where the average for the last ten years has been 33.63 in.; hence, the above assumption is very safe.

The service reservoir at Coolgardie, 328 miles inland, will be 1,653 ft. above sea-level, and 1,313 ft. above the off-take level of the Green Mount reservoir. These two reservoirs will be connected by a line of 30-in. steel pipe, with a series of rising and falling gradients, generally following the line of the Gold Fields Railway. Along this line nine pumping stations will be established for forcing the water to the summits, and down the succeeding incline the water will run by gravitation to the reservoir for the next set of pumps. The project also includes an additional set of pumps for forcing the water to the top of Mount Burges, 4½ miles beyond Coolgardie and 170 ft. above the service reservoir at that point. This greater elevation will command every part of the district for further distribution as needed. The lifts at the pumps would vary from 420 to 185 ft., with 464 to 205 pump HP., respectively, or 2,881 pump HP. in the aggregate.

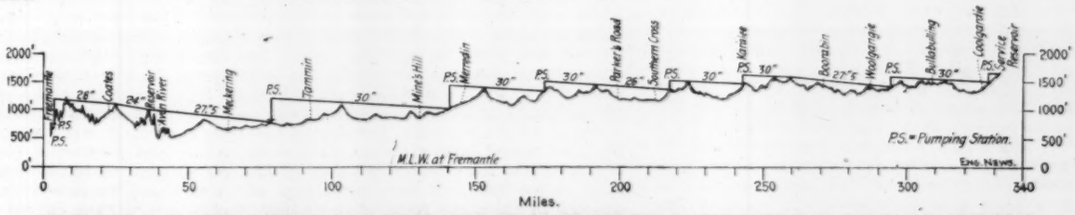
Mr. O'Connor states that estimates were made for a daily supply of one, five and ten million gallons in the original study of the project. He found that as to the steel pipes, one million gallons daily would cost from $3,500,000 to $5,000,000, depending on the size of the pipes; and the cost of delivery would vary from $1.36 to $2.04 per 1,000 gallons. A supply of five million gallons daily would cost $12,000,000 to $13,500,000, with the size of pipe used, and the cost of delivery would vary from $0.84 to $1.58 per 1,000 gallons. For a ten million-gallon supply the cost would be from $17,500,000 to $23,000,000, as before; with a cost of delivery of from 72 cts. to $1.20 per 1,000 gallons. As the smaller supply would have been insufficient for the railway, the mines and domestic purposes, and as the five million-gallon supply would only cost about 2½ times as much as a one million-gallon supply, he selected the mean daily supply. This could be extended in the future, if necessary, without change in the number or situation of the pumping stations.

The estimated capital cost of the scheme is given as follows: Pumping engines and sheds, $1,000,000; 90,000 tons of 30-in. steel main, $7,350,000; transporting pipe from Freemantle, the nearest sea port, $700,000; laying and joining pipe, $1,100,000; all reservoirs, $1,500,000; 100 miles of 12-in. distributing main, $850,000; total, $12,500,000. The annual operating expenses are placed at $1,600,000, distributed as follows: Interest on capital at 3%, $375,000; sinking fund at 3%, $375,000; maintenance, $225,000; cost of pumping 5,000,000 gallons per day, $545,000; general administration, $80,000. On this basis the water will cost 84 cts. per 1,000 gallons delivered.

The colonial legislature has approved of the project and authorized the issue of bonds to the amount of £2,500,000 to carry out the enterprise.

The importance of the project, says "The Engineer," was sufficient to warrant the appointment of a committee of experts in England to especially study the pumping machinery and pipe line. This committee was made up of Messrs. Carruthers, Deacon and Unwin, all eminent members of the engineering profession. An abstract of their preliminary report follows:

The committee finds that 5,000 gallons per day, or 9.28 cu. ft. per second, can be raised 1,313 ft. and conveyed 328 miles, without undue frictional resistance, in a main 26 to 30 ins. diameter. The total frictional resistance was figured at 1,292 ft., making the total head about 2,605 ft. For the



PROFILE OF 30-IN. STEEL PIPE LINE, 328 MILES LONG, PROPOSED FOR THE WATER SUPPLY OF THE COOLGARDIE GOLD FIELDS, WESTERN AUSTRALIA.

Chas. G. O'Connor, M. Inst. C. E., Perth, Western Australia, Chief Engineer.

three selected diameters of 26, 28 and 30 ins., the velocities in the mains would be 2.513, 2,172 and 1,888 ft. per second; for lap-welded pipes the frictional resistance per mile would be 5.103, 3.538 and 2.497 ft. respectively; and for riveted pipe this frictional resistance would be 6.159, 4.270 and 3.103 ft., respectively. To perform the specified work would require 2,743 pump HP.; or, allowing 5% for slight leakage from mains, evaporation from intermediate reservoirs, feed-water, etc., say 2,881 pump HP. A proper reserve would have to be installed and each pumping station should have a reserve to cover any exceptional leakage. As uniformity in pumping machinery was deemed of great importance, the committee divided the engines at the nine pumping stations into two groups of 464 pump HP. for the first four stations, and 205 HP. for the remaining five.

The line of pipes follows generally the line of the railway, to facilitate transportation; and, as the soil contained much salt, the pipes should, in large part, be laid above the surface. As there is no prolonged frost in Western Australia, this can be safely done, though the difficulties from expansions and contractions, due to changes in temperature, are increased. Cast-iron for pipes was excluded by the instructions, and the committee has examined a class of mild steel spiral imbedded in cement, as now used in Algeria and at the Asnieres disposal works for the Paris sewage. It does not, however, recommend them. They recommend the use of mild steel, with a tenacity of 25 to 28 tons per sq. in. and a least elongation of 16% in 8 ins.

The question of the pipe to be used is left somewhat unsettled. A patented dove-tailed longitudinal joint was examined by Mr. Unwin. This joint is made by swelling the longitudinal edges of the plate and inserting these in grooves in the opposite sides of a longitudinal bar; the bar is then closed by pressure upon these edges. In pipes made with two of these joints, five out of six broke in the solid plate under test. Under hydraulic pressure, a section 4 ft. long, 12 ins. diameter, 1/8-in. thick, with two rivetless joints, withstood 900 lbs. per sq. in. The pipe bulged, but there was no leakage at the longitudinal joint. The patentee says this pipe can be made in 27-ft. lengths. Before deciding, the committee recommends a trial on a large scale, with the view of discovering possible defects in production. Spiral-riveted pipe are not recommended; gas-welded longitudinal joints are 30% stronger than equal diameter and thickness of riveted pipe, and though they are more expensive per unit of length, they are cheaper than riveted pipe of 1/4-in. or more thickness. The committee, therefore, recommends that the pipe subject to heaviest pressure, so that the plates are 1/4-in. or more thick, should have two gas-welded longitudinal joints. They should be made in 14-ft. lengths by inserting the plain end of one into a socket in the other and then riveting. All riveted pipe should have only one longitudinal joint; and the greater part of the aqueduct will be made of such pipe, 28 and 30 ins. in diameter and 3-16-in. thick. These are to be made in lengths of 5 ft. 6 ins. as a maximum. The longitudinal joints will be double-riveted lap-joints, and the successive rings will be joined together by single riveted circumferential joints into pipes of a convenient length for transport. The question of connections between these unit lengths is taken up and butt-joints and covering rings, are not recommended, as these involve two transverse rows of rivets and two calked joints difficult to make tight. The plan now preferred is one calling for alternate lengths of larger and smaller pipe. It is interesting to American engineers to note the exact words of the committee: "In coming to this conclusion we have, of course, considered the increased hydraulic resistance, which we are satisfied is unimportant."

The internal and external corrosion of the pipes must be especially guarded against. For the Coolgardie pipes arrangements will be made to heat each length to a uniform temperature of 300° Fahr., before dipping into nearly boiling asphalt. The pipes should remain in the asphalt until they have fully acquired the temperature of the liquid, and then be drawn out vertically and allowed to cool in that position. Before dipping the pipes would be tested by hydraulic pressure up to 12 tons per sq. in. Stop-valves, scour-valves, self-acting valves and air-valves are provided for. In connection with the latter the committee recommends air-domes at each rise, made of 12-in. cast-iron pipe, 18 ins. deep and fitted by flanges to the crown of the main. Immediately above such a dome should be fixed a 3-in. stop-valve, and above that the air-valve proper. Instead of cutting a 12-in. hole in the main, it should be perforated with numerous smaller holes. In addition to this, at the more important summits the main should be enlarged to about twice the normal diameter, and chambers thus be formed in which water velocity would be reduced and the air or gas enabled to free itself from the water and escape by the air-valve. The enlargement may be made by a gradual taper in the main, both ways from the air-valve.

As coal costs $8 per ton, economical pumping engines are essential. Consequently, triple-expansion engines with surface condensers are suggested. There should be three engines at each station, one being held in reserve. Bids would be invited for these engines, and the bidder would be required to state the duty he would guarantee for his engines under test.

ENGINEERING NOTES FROM BUFFALO AND NIAGARA FALLS.

Buffalo, N. Y.

The New York Car Wheel Works.—The very successful attempts of this company to demonstrate the possibility of manufacturing chilled cast iron car wheels for high grade service equal in strength and durability to steel tired wheels have already been spoken of in Engineering News a number of times (Eng. News, Nov. 14, 1895, and Jan. 27, 1898), and space need not be taken up here in repeating familiar facts. During a visit to the company's plant in Buffalo, N. Y., however, some knowledge was obtained of the process of manufacture, and particularly regarding the preparatory work and study which have enabled these successful results to be produced, which is hardly less interesting and certainly is not so familiar to our readers. In this story also a hint will be had of what some of our most progressive manufacturers are doing in the line of technical investigation, which engineers should not fail to observe.

The first work of the above company toward developing a special quality chilled wheel for locomotive and passenger car use dates back a little over ten years. Two methods of advance were open. The first was to improve the quality of the material put into the wheel and the second was to secure a higher grade of workmanship. Naturally, the improvement in workmanship was the easier to bring about. At first the company tried to secure better material by holding out special inducements to pig iron manufacturers, but it was found that the greatest strength obtainable with the best qualities of charcoal iron was 3,000 lbs., with bars 1 in. square and 12 ins. long, broken by flexure. This was not satisfactory and the company determined to make a careful study of the whole subject of pig iron manufacture and then to undertake its production. Early in this study attention was attracted to the remarkable results obtained by the early manufacturers of Swedish pig iron. Among other things it was found that the use of bog ores had been an important factor in producing the superior quality of this early Swedish iron, and the company decided to experiment with bog ores.

The place selected for these experiments was Radnor Forges in the Province of Quebec, where the bog ores of the surrounding country had been smelted and cast into cannon for the soldiers of Louis XV. of France, and into pots and kettles for the early settlers of Canada as long ago as 1737. It seems almost incredible that one of these early furnaces should have survived, but the assertion is made that the first experiments of the company in its new field were conducted on iron smelted in the stone furnace at Radnor Forges, which was built over a century ago. These experiments were carried on for two years, and proved so successful that in May, 1892, a furnace of 50 tons daily capacity was put in operation and the Canada Iron Furnace Co. was organized to mine and smelt the bog ores of Quebec into pig iron. This company now controls some thousands of square miles of land in which bog ore is found, and also a large area of timber land, from which the charcoal for smelting it is produced. An idea of the quality of metal produced may be had from the statement of the company that a transverse breaking strength of 4,000 lbs. is readily obtained on bars 1 in. square and 12 ins. long, taken directly from the pig bed, while still greater strength is, of course, secured by remelting.

No reference has been made thus far to analytical work, but, as engineers will readily understand, it was carried on with experienced chemists and the most improved apparatus. Microscopical work was also carried on, and of late years has been greatly extended by the company, particularly in the study of the physical composition and structure of the defferent qualities and kinds of chilled iron. These tests and analyses are still kept up on every day's production of metal, the company having an especially equipped laboratory for this purpose.

A satisfactory quality of material having been secured, attention was next turned to improving the workmanship on the wheels, and the nature of this improvement, unlike the previous work of improving the material, can be witnessed at any time by a visit to the company's foundry and machine shop. Perhaps the features which most impress the engineer upon such a visit are, first, the care taken to grind the tread to a true circle, which is also truly concentric with the bore for the axle, and, second, the process of balancing the wheels. Special machines are used for both processes.

The first task is to bore the wheel for the axle. It then passes to the grinding machine. This machine has three horizontal parallel axles. The two outer axles are geared to revolve very rapidly and carry emery wheels at their ends. The middle axle revolves very slowly, and to each end of this are keyed the wheels to be ground. Each wheel thus revolves slowly between two emery wheels which bear against and grind down the tread. When the grinding and other finishing work are completed the wheels pass to the machine for testing the balance. This consists simply of two parallel bars placed perfectly horizontal at the same level. A special axle is inserted into the bore of the wheel, the ends or hubs of which rest on the parallel bars. Any lack of balance, it will be seen, will cause the wheel to revolve since the axle is perfectly round and is free to roll on the parallel bars. Should the wheel be out of balance the next task is to measure the amount. This is done by clamping to one end of the axle a bar which is graduated and carries a sliding weight much like a steel yard. By sliding this weight backward and forward it is an easy matter to find a position where it exactly counterbalances the tendency of the wheel to revolve, owing to its lack of balance. By reading the graduations the amount of overbalance is seen, and should this be over 2 lbs. a cast iron weight is riveted to the plate of the wheel between the ribs to remedy it.

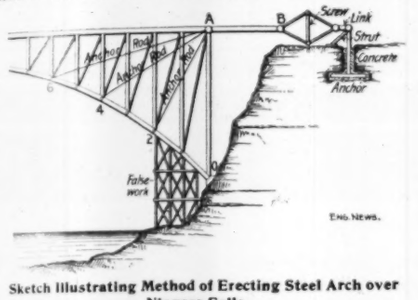
Niagara Falls, N. Y.

Outside of the various extensions of electric power development at Niagara Falls, N. Y., the principal engineering work in progress is the 840-ft. span steel arch highway bridge which is being built to replace the old suspension carriage and foot bridge erected in 1889. The history of the old suspension bridge and the general structural characteristics of the new arch were given quite fully in Engineering News of Jan. 2, 1896, and will not be repeated here. At the time of the writer's visit the skewback castings or shoes for the new arch had been set in place on the American abutment and those for the Canadian side had just been received from the manufacturers and were being unloaded at the site. Owing to the weight of these castings, 16 tons each, it was not thought advisable to take them across the old suspension bridge and they were accordingly sent by rail over the new Grand Trunk Ry. bridge and the cars were then brought to the site of the new arch on the electric railway tracks on the Canadian side.

Some inconvenience is being experienced by the contractors, the Pencoyd Iron Works, with the Canadian customs laws in shipping material across the river. All the material that enters into the permanent structure is free from duty, but it, of course, has to be entered at the Customs Office, with descriptions, vouchers and various other

forms of "red tape," which entail considerable work and delay. On the other hand, all the contractor's plant and a large portion of the material used temporarily in erection, which are employed on the Canadian side, have to pay duty, 90% only of which can be got back when this plant and material are returned to the United States. Besides the depreciation, a loss amounting to 10% of the total duty must, therefore, be figured on all this plant.

In erecting the new arch much the same method will be followed as was adopted on the Grand Trunk Ry. arch, completed last year, about a mile further down stream. Beginning at the skewbacks, falseworks will be built out as far as the water's edge, which is about the second panel point of the arch on each side. Beyond these points a series of temporary anchor rods attached to every alternate panel point will hold the halves of the arch in place until they meet at the center, when the anchor system will, of course, be removed. The nature of these anchorages is best explained by the accompanying diagram, sketched from memory. This sketch is not to scale and is not intended to show at all accurately the



Sketch Illustrating Method of Erecting Steel Arch over Niagara Falls.

length or number of panels in the arch truss. It will, however, indicate the general method of erection. As soon as the post O A is erected, it is attached by the member A B to the anchorage which consists of the toggle, screw, link, strut, and anchor, indicated by the diagram. By means of the falseworks the arch is then completed out to panel point No. 2. The anchor rod, A 2, is then placed, and the arch built as a cantilever to panel point No. 4. The anchor rod, A 4, is then placed and the former operation repeated until the two halves of the arch meet at the center.

For the member A B the top chord of the permanent inverted bow-string truss, which will span the gap, A B, will be used. The office of the toggle and screw is, of course, to permit the anchor system to be lengthened or shortened to accomplish the necessary adjustments when the center connection comes to be made. The offices of the strut, link and anchor need no explanation.

As the new arch is about on the line of the old suspension bridge, being about 16 ft. off at the American end only, the steelwork of the arch will be erected by means of a traveler mounted on the top chords of the stiffening trusses of the suspension bridge. This traveler had already been mounted in place at the time of the writer's visit.

Despite the fact that this new arch removes the last of the present well-known suspension bridges across the Niagara Gorge, it will very likely also result in another suspension bridge being erected further down the river at Lewiston. The writer was told by Mr. R. S. Buck, the engineer in charge of the new arch, that arrangements had been partially completed for re-erecting the bridge, which is now being removed, on this new site. As many of the readers of Engineering News will remember, the Chief Engineer of the new Niagara arch is Mr. L. L. Buck, M. Am. Soc. C. E., of New York city.

BIDS FOR BUILDING THE PROPOSED GOVERNMENT armor plate factory were opened at Washington on Jan. 29. There were over 30 bids in all, but only two of these were for the entire plant, the others were for portions of it, such as site, buildings or tools. The Huntington, W. Va., Chamber of Commerce offered to furnish the entire plant for $3,225,905. The John P. Holland Torpedo Boat Co., of New York, offered to build it "for a sum of money and within a period less than estimated by the Armor Factory Board in its report." The Rarig Engineering Co., Columbus, O., offered to supply the buildings, furnaces, boilers, etc., required for $868,000, and the Chamber of Commerce of Columbus offered to donate the sum of $500,000, and Samuel Caldwell, of the same city, offered to donate 150 acres of land for a site in event of the acceptance of the bid of the Rarig Engineering Co. Offers of sites gratis or for a nominal sum of money came from Muskegon, Mich.; Youngstown, Ohio; Escanaba, Mich.; Duluth, Minn.; Ensley, Ala.; Lorain, Ohio; Winthrop Harbor & Dock Company, of Chicago; Sheffield, Ala.; Waukegan, Ill.; Detroit, Mich.; Peoria, Ill.; Marquette, Mich.; West Point, Va.; Elizabeth, Tenn.; Menominee, Mich.; Marion Center Township, Grant County, Ind.; Marion, O., and Aniston, Ala. Some of the big Western tool concerns came forward with offers to supply machinery needed for the plant.

NEW YORK'S HARBOR, according to a pamphlet issued by Mr. John W. Ambrose, has not received its fair share of improvement appropriations in the last hundred years, as compared with other and much less important ports. Mr. Ambrose has compiled the figures for 1790-1890, with some astonishing results. He leaves out the work on Harlem River and at Hell Gate, as not properly coming under harbor work, and finds that up to 1896 New York has received $2,252,000 for the improvement of its harbor. Mr. Ambrose says that for every 100 cents collected in import dues by the Federal Government at all the ports of the country, between 1856 and 1896, 69 cents were collected at the Port of New York. Yet, out of every 100 cents expended by the government in the last 106 years for the improvement of all rivers and harbors, the harbor of New York has received only one-half cent; the remaining 99½ cents went to other points. As one out of many examples quoted by him, $2,281,155 has been expended in securing a 6-ft. navigation on the Kentucky River, as compared with the $2,522,000 spent on New York's harbor. The total value of the foreign imports and domestic exports at the port of New York was $914,391,988 in 1895; or 300 times the total value of the tonnage on the Kentucky River for 1896; this value being $2,963,246 on 269,386 tons.

THE NICARAGUA CANAL COMMISSION has about completed its examination of the Western division, says a Managua item. Maps are being made on a scale of 400 ft. to one inch, and geological sections are being prepared showing probable formation for several hundred feet in depth. The Commissioners now propose to travel on foot from the site of the Ochoa dam to the Caribbean mouth of the canal, at the rate of about 3 miles per day, and to personally examine all parts of this route. All the members of the party are reported as well.

THE USE OF CLAY IN MACADAM ROAD construction was noted in our issue of Jan. 20, in an abstract of a paper read before the Engineers' Club, of Philadelphia. Mr. Benjamin Franklin, the writer of that paper, now sends us a letter of Mr. H. I. Budd, State Commissioner of Public Roads of New Jersey, in which he expresses himself as follows: For country roads he approves of light macadam construction, 6 to 8 ins. deep, thoroughly watered and rolled, with 1¼ to 1½-in. stone, and very little, if any, clay used. Mr. Budd says the best road now in the State is on a sand bed with clay entirely discarded. His objections to a too liberal use of clay is that it will keep the stones from binding, and the screenings and clay will bunch, if the contractor is not closely watched, and a ravelling road, and ruts in wet weather, will result. He has drawn up road specifications with clay entirely left out.

HARDWOOD PAVEMENTS IN LONDON seem to be growing in favor, the London County Council having recently extended the period for repaying a loan made by it on such pavements from seven to ten years. In another case ten years were given for the repayment of a loan for Jarrah, Karri and oak paving, against five years for creosoted deal blocks. These loans are made by the London County Council to vestries or districts within its jurisdiction. The London "Contract Journal," from which we glean the above, states that "the extension of the time of repayment will probably give a fillip to wood paving, and many towns which have heretofore hesitated in putting down hard wood will do so no longer."

THE MAGNOLIA METAL BRITISH PATENT is to be revoked, according to an order issued by the English courts on Jan. 13. The patent was No. 8,655, of 1890, and petition for its revocation was brought by the manager of a rival maker of bearing metal alloys in 1893. The judge who issued the order for the revocation of the patent gave as the reason for the order, first, that metal made according to the patented process was sold in the ordinary way of business in this country before the date of the patent, and, further, that a competent analyst using reasonable care could have ascertained the composition of the metal so sold, especially the presence of bismuth therein.

THE PRODUCTION OF PIG IRON IN THE UNITED States in 1897, according to the statistics of the American Iron and Steel Association, amounted to 9,652,680 gross tons, a gain of 1,029,553 tons over 1896. The production of Bessemer pig was 5,795,584 gross tons, an increase of 1,140,629 tons over 1896.

THE LOSS BY OXIDATION of cast iron when melted in a cupola is discussed in a paper by Mr. Thomas D. West, read before the Pittsburg Foundrymen's Association, Jan. 31. He made a series of experiments in a "twin-shaft" cupola on sand and chill castings, and also on chill castings protected with various coatings or washes. It was found that the sand castings oxidized in melting to a greater extent than either the protected or unprotected chill or sandless castings. The average losses were as follows: Sand iron, 5.8%; sandless iron, 3.4%; chilled iron, with lime wash, 3.8%; with graphite wash, 3.4%; with silicate of soda wash, 2.9%.

THE PERFORMANCE OF A FEED WATER HEATER attached to a condensing engine is given in the February issue of "Power." The record is of interest, as reports of tests of exhaust steam feed water heaters in actual service are not often obtainable. We give it in condensed form below:

Heating surface	234 sq. ft.
Feed water temp., initial 32°, final	98°
Average increase of temperature	65½°
Vacuum obtained in engine	27 ins.
Boiler evaporation, equiv. from and at 212°, per hour	14,400 lbs.
Equivalent boiler horse-power	420 HP.
Heating surface of heater per boiler HP.	0.55 sq. ft.
Average heat transferred per sq. ft. of heating surface per hour per degree of average difference in temperature of exhaust steam and feed water	87 B. T. U.

FOREST CULTURE EXPERIMENTS, under the auspices of Cornell University, are suggested by Governor Black, of New York. He proposed the passage of a bill leasing to Cornell for 25 years about 25,000 acres of land outside of the present forest reserve. By the aid of an annual appropriation of, say $25,000 for the first year, the college authorities should engage in forest culture, study the best means of preservation and cultivation employed in France and Germany, plant young trees and trim trees at the proper time, and cut down and sell "ripe" trees. The aim would be to make the tract a paying investment to the state; and if the experiment were successful it could be applied to the whole 800,000 acres of state forest land in the Adirondacks, now unremunerative.

EXPERIMENTS ON THE FRICTION LOSSES IN HYdraulic packing are described in an article by Mr. Walter Ferris, in the "American Machinist" of Feb. 3. The experiments were made on a hydraulic intensifier at the Pencoyd Iron Works, which has two movable plungers, one working inside the other, of 14¼ and 17¾ ins. diameter, respectively, and a ram 8 ins. diameter, working in the inner plunger. The area of the ram is to that of the smaller ram as 1 to 3.17, and to that of the larger ram as 1 to 4.93. When the outer ram is latched so as to prevent its moving, the intensified pressure would be 3.17 times the initial pressure, and when both rams are free the ratio of pressures would be 4.93, provided there were no friction in the packing. The "Taschenbuch der Hutte" gives a formula for the friction loss of packed stuffing boxes for water cylinders as follows: F = K p D, in which F = total frictional loss in lbs., p = pressure in lbs. per sq. in., and D = diameter of plunger in ins. K is a coefficient, which depends on the kind and condition of the packing. The following values are given: For cotton or hemp, lose or braided, dipped in hot tallow; plungers smooth, glands not pulled down too tight, packing retaining its elasticity; dimensions such as usually occur, K = 0.072. Same conditions, after packing is some months old, K = 0.132. Materials the same, but packing hard, unfavorable conditions, etc., K = as much as 0.299. Mr. Ferris takes the mean value of K = 0.2 for calculating the probable losses due to each stuffing joint in the intensifier, and compares the results with those estimated by the builders and those obtained by experiment, as follows:

Experiments.	1.	2.	3.	4.
Diameter of rams, ins.	8 and 14¼	8 and 14¼	8 and 17¾	8 and 17¾
Initial pressure, lbs. per sq. in.	285	475	335	350
Calc. intensified press., no friction	905	1,505	1,650	1,725
Pressure calculated by formula	860	1,433	1,572	1,643
Pressure estimated by builder	813	1,354	1,552	1,620
Pressure obtained by experiment	750	1,450	1,450	1,510
Efficiency of machine, formula	.95	.95	.953	.953
" " " estimated	.90	.90	.945	.945
" " " actual	.83	.905	.88	.875

The highest efficiency, it will be noted, was obtained when the highest initial pressure was used. With the lower pressures the actual efficiency was much lower than that estimated by the builders or that calculated from the formula.

THE MAGDEBURG, GERMANY, COMMERCIAL HIGH school, lately founded, will include the following nine departments of instruction: (1) Modern languages, including English, French, Spanish and Russian; (2) political economy, finance and statistics; (3) commercial exchange and law; (4) commercial geography and history; (5) insurance, banking, transportation and customs; (6) technology, physics, chemistry and descriptive natural history; (7) state

and citizens' rights; (8) commercial intercourse; (9) mathematics. There are already higher commercial schools at Dresden, Leipsic, Osnabruck and Gira.

A 40-FT. CHANNEL IN NEW YORK HARBOR, 2,000 ft. wide, is the purport of a bill introduced into the House of Representatives by Congressman Amos J. Cummings, of New York city.

BOOK REVIEWS.

MACHINE DESIGN.—Part I., Kinematics of Machinery. By Forrest R. Jones, Professor of Machine Design in the University of Wisconsin. New York: John Wiley & Sons; London: Chapman & Hall Ltd. Cloth, 8vo.; pp. 155; 134 illustrations. $1.50.

We quote the following from the preface:

In these notes an attempt is made, first, to give as clearly and concisely as possible the principles of mechanical motion in such a manner that their application can readily be made to any mechanism for determining the motion of any of its parts; then to show the method of dealing with such problems as the designer meets daily. Long and tedious discussions have been avoided as far as possible. Subjects such as toothed gearing and couplings are taken up only to the extent of the forms that are in most common use.

This work seems to be well suited for a brief course in kinematics in engineering schools, but it cannot be expected to take the place, as a book of reference, of larger works on the same subject. The author's treatment is in general very brief, but clear, and the illustrations and typography are excellent.

HANDBUCH DER INGENIEURWISSENSHAFTEN; DER EISENBAHNBAU.—Edited by F. Loewe and Dr. H. Zimmerman. Wm. Englemann, Leipzig, 1897. Paper, 7½ × 11 ins.; pp. 394; illustrated; unbound, 12 marks; bound, 15 marks.

This is the fifth volume of a "Hand Book of Engineering Knowledge," which is planned on the very extensive scale for which German engineering works are often notable, and it takes up the subject of "Railway Construction," exclusive of preliminary operations, substructure and tunnels, which are treated in another volume. Broadly speaking, the subjects treated come under the head of what in America is called track and track work. Naturally the book is devoted to German practice. The book is lavishly illustrated and has a good index.

FLOODS OF THE MISSISSIPPI RIVER.—Prepared under the direction of Willis L. Moore, Chief of Weather Bureau, by Park Morrill, Forecast Official, in charge of river and flood service U. S. Department of Agriculture, Weather Bureau, Washington. Paper; 11¾ × 9¼ ins.; pp. 79; 58 maps and diagrams.

In this report the drainage basin of the Mississippi River and its great tributaries is described in detail. In this connection it is stated that owing to faulty nomenclature the length of the Mississippi River is assumed to be only 2,485 miles. But in point of fact the Missouri River is the proper prolongation of the Mississippi; and the distance from the mouth of the Mississippi to the source of the Missouri is 4,190 miles; making a watercourse only rivalled in length by the Nile and the Amazon. The exact length of the two latter rivers is not known, but is usually estimated at about 4,000 miles for each. The region drained by the Mississippi covers 1,240,050 sq. miles, or 41% of the area of the United States, exclusive of Alaska. On an average it annually carries to the sea 150 cu. miles of water. At certain seasons it can be ascended by steamers for a distance of 3,950 miles from the Gulf of Mexico; and the navigable waters of the Mississippi and its tributaries aggregate 15,000 miles. The catchment basin of this great river covers 56° of longitude and 21° of latitude, with a great variety of climate.

A second part of this report deals with the normal precipitation and drainage, normal discharge and normal river stages. The normal annual discharge from the Mississippi at its mouth is figured at 724,360 million cu. yds.; and with the outflow of bayous Archafalaya and La Fourche added, as being really other mouths of the river, the annual outflow is 785,190 million cu. yds.; or a ratio of discharge to downfall of 0.247. The great floods of this century are next described, commencing with that of 1815. The highest stage for these floods, at St. Louis, Memphis, Vicksburg and Carrollton, is given for the years 1872-1897 inclusive, and the spring flood of 1897 is described in detail. The maps and charts accompanying this report are especially interesting and valuable for reference.

BIBLIOGRAPHICAL DECIMAL CLASSIFICATION AS APPLIED TO RAILWAY SCIENCE.—By L. Welsenbruch, Principal Engineer to the Belgian State Railways, General Secretary of the Permanent Commission of the Railway Congress. Brussels: Bibliographical International Institute Office, 1 Rue de Musee. Paper, 9½ × 7 ins.; pp. 61.

In connection with the publication of the proceedings of the International Railway Congress, now in existence for ten years, and that of a summary of the contents of the many technical periodicals received by the Congress, some intelligent classification of railway articles became necessary, so that an index could be issued. The author critically examined all methods of index-making in use and found serious difficulty in the usual dispersion of kindred subjects under any alphabetical arrangement. These dispersions made research laborious, and something better was sought for. He finally settled upon the plan adopted by the International Institute of Bibliography founded in Brussels at the close of 1895. This system is based upon the decimal classification proposed by Mr. Melvil Dewey, and the Institute is established, under the patronage of the Belgian Government, for the publication of a repertory of universal bibliography. By this plan the whole of human knowledge is gathered into ten classes, numbered from 0 to 9, as follows: 0, General Works; 1, Philosophy; 2, Religion; 3, Sociology; 4, Philology; 5, Natural Sciences; 6, Useful Arts; 7, Fine Arts; 8, Literature; 9, History. Each of these main classes is divided into ten divisions, and the subdivisions are again decimally divided as long as the subject warrants it. For example, main class 6, or Useful Arts, would be divided and represented as follows: 60, General Works upon Useful Arts; 61, Medicine; 62, Engineering; 63, Agriculture; 64, Domestic Economy; 65, Communication, Commerce; 66, Chemical Technology; 67, Manufactures; 68, Mechanic Trades; 69, Building. Taking one of these divisions, 65, or Communication and Commerce, for example, its divisions would stand as follows: 650, General Works upon Commerce and Communication; 651, Office Equipment and Methods; 652, Writing Materials, Type Writers, Cipher, etc. One of these latter divisions wiuld be subdivided and represented by 652.1, 652.2, etc.; and the division can be extended by 652.20, 652.21, 652.22, etc., to an indefinite limit. The author admits that this system has its objections; but he contends that they amount to little when compared with the advantages. The scheme is not yet put forward as a perfect work; but any modifications made in work already done would only affect the last figure to the right of each number. But the author believes that a figure notation thus applied to a methodical classification constitutes a real universal language. He then describes card catalogues, etc., after the general plan of the American Library Association. The Permanent Commission of the Railway Congress has decided to publish both a bibliography of books and a bibliography of articles on railway matter in technical periodicals; and this matter will be so printed, on one side only, as to be available for use in slips on card catalogues. The author believes that in this manner the more specialized, more detailed, up-to-date and more easily published magazine article will be largely substituted for the book, which is too apt to be out of date when published. It would make the magazine article accessible, and remove its chief objection—that of being difficult to locate, of disappearing too quickly and being too easily forgotten. The book concludes with a bibliographical classification of railways on the decimal system, and an alphabetical index of all matter pertaining to railways, with the numbers used in the universal decimal classification.

ENGINEERING AND ARCHITECTURAL JURISPRUDENCE.—A Presentation of the Law of Construction for Engineers, Architects, Contractors, Builders, Public Officers and Attorneys at Law. By John Cassan Wait, M. C. E., LL. B. New York: John Wiley & Sons. Cloth; 9 × 5⅝ ins.; pp. 905; cloth, $6.00; sheep, $6.50.

This monumental work on the law of contracts should be of unlimited benefit to contractors and engineers, and to all interested in engineering work of any sort. The author was, in 1887, an Instructor in Engineering at Harvard University, after graduating as an engineer from Cornell University. Being called upon to prepare specifications and contracts for engineering works, and having found this labor, as based upon old forms, usually resulting in misfits and consequent litigation, he undertook to study for himself the law upon the subject. To this end he entered the Harvard Law School, and spent three years in acquiring a general knowledge of the law, customs and usages prevailing in the building professions and trades. Further years have been expended under unusually advantageous surroundings, in collecting, from this country and England, matter pertinent to engineering and architectural jurisprudence; and the range covered is indicated by the fact that in this work some 5,000 cases are cited which have a direct bearing upon the question at issue.

In the space available here little more than a synopsis of the contents of this treatise can be attempted. The law of contracts in general is first discussed. This deals with the essential elements of a contract, the parties who may contract, artificial or corporate bodies, the subject matter of contracts, consideration for, mutual consent and understanding, assignment of contracts, terms of, statutes of fraud and limitation, verbal agreements, contract stipulations and the multitude of side issues growing out of these heads.

In the treatment of this matter Mr. Wait is clear and concise. The salient question discussed heads the paragraph in bold-faced type, easily read; and foot-notes refer to the cases cited in support of the position taken. Under the main heading of "Bids and Bidders," we have the rights and liabilities of bidders, as fixed or interpreted by law, and with reference to contracts for both public and private work.

The "Construction Contract" takes up Part III., and relates to the phraseology, terms, considerations, stipulations and the provisions and requirements of contracts, and their interpretation, construction and force. This part is of especial interest to the engineer and to the architect. It defines their position as arbitrator, umpire or referee, and their duties, powers and obligations in a judicial capacity. It discusses the form, substance and requirements of their certificates; the conclusiveness of such certificates and correction of errors in them; the delegation of their duties to assistants, and the conditions under which contractors may sue for recovery without such certificates. The question of fraud, or conspiracy between engineer and contractor, and secret interest in the contract by the engineer, is fully taken up. The appointment of arbitrators and an umpire, in matters of doubt or dispute, forms a chapter by itself. That very fruitful source of litigation, extra work and alterations, additions, omissions and substitutions for contract specifications, is treated at length; and this part is followed by chapters on custom and usage in construction work, owner's liability for acts of contractor, non-performance, or impossibility of performance, of contracts, and payments, in progress and final.

Part IV. is another and most interesting division of the work. It discusses the employment of engineers and architects; their term of service, dismissal and extra work; their property rights in plans, specifications, and drawings; their liability as professional men, requiring them to be competent and skilful and to exercise due care; their liability when acting in a judicial or discretionary capacity, or as public officers; their compensation and protection by law; and, finally, their employment as expert witnesses. The latter chapter covers the consultation with their employers, preparatory study, behavior in court and their compensation.

Engineers, and especially young engineers, will find much in this work that will upset some very generally held notions as to their actual power over and relation to the contractor. In discussing the provision that "the engineer shall be the sole judge and decide all questions," the author remarks that the object of this provision is to create a tribunal to determine all questions arising with regard to the work. Such an agreement is to all intents and purposes a submission to arbitration, with the engineer as arbitrator. But the arbitrator should be a disinterested party, and this the engineer is not. He is paid by the company to direct its works, promote its interests and to be ever mindful of its rights and dues; on the other hand, he owes no duties to the contractor, and is under no obligation to protect his interests, or assist him in his affairs. In performing his duties, therefore, says the author, the engineer must strictly act within the expressed terms of the contract, and he can neither go beyond nor behind it. The law makes the engineer's determination conclusive only in regard to the items which are clearly within the powers conferred upon him in the contract. He can not refuse the contractor a final estimate for example, because the subcontractors are not paid, when the completion of the work makes this certificate due and sub-contracts are not dealt with in the contract. In a contract undertaken for a lump sum, the engineer cannot deduct a large amount on account of an error in computing the quantities in the preliminary estimates. If the engineer's estimates and decisions are to be both made final and conclusive, this must be expressly provided for in the contract. In other words, the engineer's power is subordinate to the contract; he cannot alter its express provisions, nor add to its requirements, and his decisions are only conclusive with regard to work described in the contract and specifications. If he be sole judge of the work, its quality and character, he cannot accept what the contract forbids, nor demand what the contract does not require; and with regard to materials described in the specifications, it is no answer that other materials are as good or suitable for the purpose as those specified.

The chapter on the expert testimony of engineers is an especially valuable one, in its hints as to necessary preparation, behavior before the court, and the result of careless or hasty testimony upon the engineer's reputation.

Under present conditions experts too generally regard themselves as champions of a cause, and their testimony is a studied argument in favor of the side for which they have been called. It is this position which has led the courts to have so little confidence in expert testimony, and to liken the belief of experts to Faith as defined by the Apostles,—"the substance of things hoped for, the evidence of things not seen." As a rule, however, the judgment of engineers, chemists, and physicians, says Mr. Wait, is no more liable to bias than is that of a lawyer defending a client. Questions of law are frequently as much matters of opinion as questions of science, and every case that is reversed by a higher court is a record of a mistake in the court below. Mr. Wait indicates the method by which candid and unbiased opinions of experts can be obtained, which is by giving the court the power to summon skilled witnesses of acknowledged authority, on behalf of the court, or state. This is the practice in vogue in France and in Germany, and it must be sooner or later adopted in this country.

Any number of equally interesting and important notes might be made on the contents of this volume, but space forbids, and we will only repeat that it is a work that should be owned, read and used for constant reference by every engineer in independent practice, and by every contractor. We say every contractor advisedly, for we feel safe in saying that it will be the exception when a contractor's own attorney will have the special knowledge contained in this book, and will prove so safe and reliable an adviser.